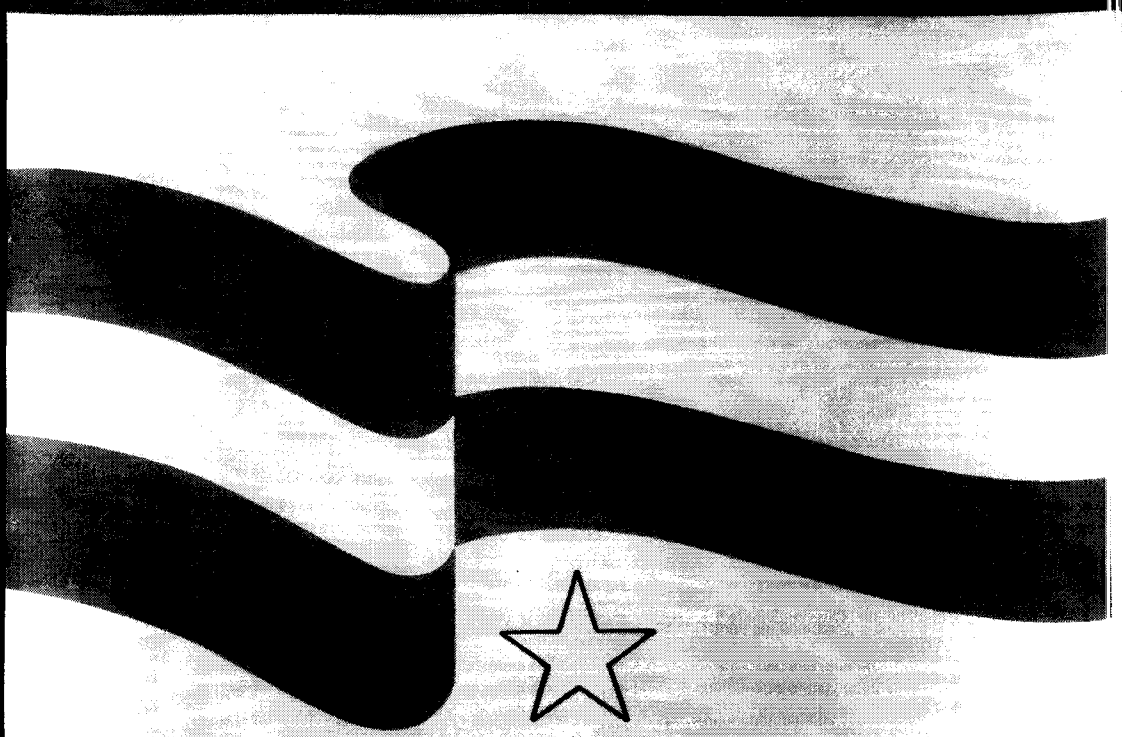

POSTSERVICE MORTALITY AMONG VIETNAM VETERANS

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
PUBLIC HEALTH SERVICE
CENTERS FOR DISEASE CONTROL

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Coleen A. Boyle, Pierre Decoufle, Robert J. Delaney,
Frank DeStefano, Melinda L. Flock, Martha I. Hunter, M. Riduan Joesoef,
John M. Karon, Marilyn L. Kirk, Peter M. Layde, Daniel L. McGee,
Linda A. Moyer, Daniel A. Pollock, Philip Rhodes,
Mark J. Scally, Robert M. Worth.

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PUBLIC HEALTH SERVICE
Centers for Disease Control
Center for Environmental Health
Atlanta, Georgia 30333

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TABLE OF CONTENTS

SUMMARY

This report presents results of the mortality component of the Vietnam Experience Study (VES). The VES is a historical cohort study in which the health of 9,324 Vietnam veterans is compared with that of 8,989 Vietnam-era veterans who served in Korea, Germany, or the United States. Eligibility for the study was limited to male U.S. Army veterans who first entered military service between 1965 and 1971, served a single term of enlistment, and were discharged in the enlisted pay grades E-1 to E-5. Participants were randomly selected from computerized lists of accession numbers of military personnel files of Army veterans discharged during the relevant time period. Ascertainment of deaths occurring after discharge from active duty and before January 1, 1984 was done using several methods, ranging from computer linkages to personal contact with next-of-kin, resulting in practically complete death ascertainment for both cohorts. In addition to an analysis based on death-certificate cause of death, a medical review panel independently assigned an underlying cause of death using information from supplemental sources, including hospital records, autopsy reports, personal physician contacts, and coroner and law enforcement files.

Veterans of service in Vietnam were found to experience a 17% higher rate of postservice mortality than veterans who served in Korea, Germany, or the United States. As expected in such a study of young men, the majority of deaths in both cohorts were due to external causes. The most noteworthy pattern of overall mortality was the changing difference between Vietnam and non-Vietnam veterans over time. During the first 5 years postdischarge, mortality among Vietnam veterans was 1.45 times the death rate of non-Vietnam veterans (95% CI=1.08-1.95). During the succeeding years, there was virtually no difference between the two groups (RR=1.01, 95% CI=0.79-1.28). This pattern was generally consistent across most demographic and military subgroups of veterans. However, there was some indication that Vietnam veterans with some physical impairment at entry into service, those who were drafted into service, and those discharged before 1970 were at an especially high risk of dying during the first 5 years after discharge compared with their non-Vietnam counterparts. When the data were stratified by type of military unit and military occupational specialty, the relative risks of mortality were similar for those more or less likely to have engaged in combat. Unlike the finding of especially high excess mortality among Australian Vietnam veterans who served in the Engineer Corps, no excess was found among engineers in this study.

External causes accounted for most of the increased mortality in the early postservice period. Deaths due to motor vehicle accidents (MVA) were significantly increased during this time (RR=1.93, 95% CI=1.16-3.22). A more detailed examination of MVA deaths did not indicate any particular factor that could explain the overall excess in Vietnam veterans. The increased risk did not appear to be related to elevated blood alcohol levels at the time of death, and the risk was evident regardless of the type of MVA. Drug use information on MVA victims was limited, and the medical review panel identified only one drug-related MVA death from available supplementary records. Suicide and homicide showed similar increases (RRs=1.72, 95% CI=0.76-3.88 and 1.52, 95% CI=0.59-3.91, respectively) in the early follow-up period but the rate ratios were not statistically different from 1.0. Mortality from accidental poisoning was elevated throughout the follow-up period, although the number of such deaths was small. Most of these involved the use of illicit drugs. When all drug-related deaths identified by the medical review panel were analyzed together, there appeared to be an increasing relative risk with number of years since discharge. The only natural cause of death category for which the mortality rate among Vietnam veterans differed from that among non-Vietnam veterans was circulatory system diseases. Vietnam veterans had a surprising deficit in such

deaths relative to non-Vietnam veterans (RR=0.49, 95% CI=0.25-0.99). Statistical adjustment for potential confounders had little effect on the results, except for suicide where adjustment increased the RR in the early postservice period to 2.54 (death certificate data).

These results are similar to previous observations of increased mortality from external causes among World War II and Korean War combat veterans. In contrast, broader cross sections of World War II veterans, including combat and noncombat groups, showed no difference, or even a deficit, in postdischarge traumatic deaths, as did non-Vietnam veterans in this study. Although the influence of factors specific to the Vietnam experience cannot be completely ruled out, our findings and those of prior studies suggest that the postservice excess of traumatic deaths among Vietnam veterans is probably related to unusual stresses the veterans endured while stationed in a war zone.

The pattern of drug-related mortality among Vietnam veterans seems to differ from that of external causes of death. The drug-related excess is most pronounced among draftees, among those whose jobs involved combat operations, and among those who served in Vietnam during 1968 and 1969, the years of heaviest combat activity. Thus, the increased death rate from drug-related causes among Vietnam veterans may be linked to intensity of combat exposure rather than to a general effect of the Vietnam experience.

This mortality assessment of Vietnam veterans is an incomplete evaluation of their health experience. Additional data on the present and past health status of living Vietnam veterans will be forthcoming from the health interview and the medical, psychological, and laboratory evaluation components of the VES. Furthermore, since this group of veterans has not yet reached the age-span where chronic diseases have an important impact on mortality, continued monitoring of mortality among VES participants may provide additional insights.

1. INTRODUCTION

In response to Vietnam veterans' concerns about their health, the Centers for Disease Control (CDC) has proposed three distinct, but related, epidemiologic studies:

a) The ***Vietnam Experience Study*** (VES) is a historical cohort study to ascertain whether adverse health effects are associated with service in Vietnam.

b) The ***Agent Orange Study*** is a historical cohort study to ascertain whether men with possible exposure to the phenoxy herbicide code-named Agent Orange while in Vietnam, have experienced any health problems related to that exposure.

c) The ***Selected Cancers Study*** is a concurrent, population-based case-control study to ascertain whether Vietnam veterans are at increased risk of particular types of cancer that occur too infrequently to be evaluated adequately in the two cohort studies.

The first two studies include three methods of health assessment: a mortality assessment, health interviews of living veterans, and a clinical, psychological, and laboratory assessment of a random sample of those who complete the health interview. This report presents results of the mortality component of the VES.

1.1. GENERAL BACKGROUND OF THE STUDY

Many Vietnam veterans believe that their service in Vietnam and, more specifically, their exposure to Agent Orange have increased their risks for a wide variety of illnesses. Health concerns include dermatologic conditions, cancer, and congenital anomalies among their offspring. Unfortunately, little objective evidence about the physical health of Vietnam veterans is available.

In response to these concerns and the lack of objective data, the United States Congress passed two laws mandating that the Veterans Administration (VA) conduct epidemiologic studies of the health of veterans of the Vietnam conflict. Public Law 96-151 (1979) specifies the conduct of an epidemiological study of U.S. veterans to assess the possible health effects of exposure to herbicides and associated dioxins during the Vietnam conflict.[1] Public Law 97-72 (1981) expands this mandate to include the study of other environmental exposures that may have occurred in Vietnam.[2] In January 1983, the responsibility for the design, conduct, and analysis of studies responsive to these laws, first assigned to the VA, was transferred by an Interagency Agreement to CDC. In May 1983, CDC prepared a draft protocol that underwent extensive peer review,* and in November 1983, issued a revised protocol.[3]

1.2. PREVIOUS MORTALITY STUDIES OF VIETNAM VETERANS

When the present study was designed, little was known about the long-term physical health consequences, including death, of military service in Vietnam. Since that time, six mortality studies of Vietnam veterans have been reported. Five were conducted in the United States, and the sixth dealt with Australian military personnel who served in Vietnam.

The first of the five mortality studies of U.S. servicemen was conducted by the U.S. Air Force.[5] It was a retrospective cohort study of Air Force personnel involved in the aerial herbi-

* This included formal reviews by the Office of Technology Assessment Agent Orange Advisory Panel, the DHHS Advisory Committee on Special Studies Relating to Possible Long-Term Health Effects of Phenoxy Herbicides and Contaminants ("Ranch Hand Panel"), the Agent Orange Working Group Science Panel, and a Centers for Disease Control Ad Hoc Review Panel.[4]

cide spraying operation in Vietnam designated "Operation Ranch Hand." Although the differences were not statistically significant, Ranch Hand flight crews had slightly lower death rates than other Air Force personnel of similar military rank and occupation, and Ranch Hand ground personnel had slightly higher death rates than the comparison group. However, since the principal concern of the Ranch Hand Study was the adverse health effects of herbicide exposure in this unique group of veterans, the relevance of the Ranch Hand results to our study is questionable.

Four other mortality studies of U.S. Vietnam male veterans were conducted by the State health departments of Massachusetts, New York, Wisconsin, and West Virginia.[6-9] All were death certificate-based proportionate mortality studies, which are useful in detecting unusual patterns in cause-specific deaths. However, without actual mortality rates it is difficult to determine whether an increased frequency for one cause of death reflects a true rise in risk for that cause or a deficit in other causes of death. In addition, the Massachusetts and West Virginia studies are based on nonrandom samples of deaths, and it is unclear whether some selectivity in identifying deaths occurred.

The Massachusetts study compared causes of death among Vietnam veterans with those among Vietnam-era veterans who did not serve in Vietnam and among nonveteran males from Massachusetts.[6] Vietnam service was determined from a computer-based list of veterans who had applied for a military service bonus awarded by the Massachusetts Office of Veterans Services. The most striking finding of the study was a markedly increased number of connective tissue cancers in Vietnam veterans (9 observed versus 1 expected, based on the mortality pattern of non-Vietnam veterans). No other causes of death were significantly elevated in Vietnam veterans.

The study by the New York State Department of Health compared cause-specific mortality patterns of New York State Vietnam veterans with those for non-Vietnam veterans.[7] Vietnam service status was determined by matching the computer-based record systems of the Defense Manpower Data Center (Department of Defense) and the VA Beneficiary Identification and Record Locator Subsystem (BIRLS). The strongest association with Vietnam service involved deaths from nonmotor-vehicle injuries of transport.

The Wisconsin study examined mortality among Vietnam veterans, other Vietnam-era veterans, veterans not of the Vietnam era, and nonveterans within the State of Wisconsin.[8] Deaths among Vietnam era veterans were identified from a Wisconsin Department of Veteran Affairs Graves Registration File, and Vietnam status was determined from military personnel files. Relative to other Vietnam-era veterans, those who served in Vietnam had excess mortality from cancer of the pancreas, diseases of the genitourinary system, and pneumonia An excess of connective tissue cancer was noted when Vietnam veterans were compared with veterans not of the Vietnam era (5 deaths observed versus 0.3 expected). No significant excess was noted, however, when Vietnam veterans were compared with other Vietnam era veterans or with nonveterans (5 deaths observed versus 3 expected).

The West Virginia study examined causes of death among deceased Vietnam-era veterans who had been given a military service bonus by the State Department of Veterans Affairs.[9] Among 615 such veterans who had served in Vietnam there was a slightly larger proportional mortality ratio (PMR=1.11) for suicide and for motor-vehicle accidents (PMR=1.07), using for comparison the general male population of the same age. Non-Vietnam veterans exhibited about the same results for motor-vehicle accidents, but their suicide experience was not

unusual. Both Vietnam and non-Vietnam veterans experienced increased mortality from cancer of the respiratory tract, but increases in relative frequency of death from cancer of connective tissues (3 observed versus 0.7 expected) and Hodgkin's disease (5 observed versus 2.4 expected) were confined to Vietnam veterans. When Vietnam veterans were compared directly with non-Vietnam veterans, these excesses persisted, and, in addition, there were more deaths among Vietnam veterans from testicular cancer (3 observed versus 0.6 expected).

The study of Australian Vietnam veterans was a retrospective follow-up of mortality from 1965 to 1981 among 19,205 Vietnam veterans and 25,677 veterans who did not serve in Vietnam.[10] Both groups had a lower overall mortality rate than the general population of Australian men of similar age, but Vietnam veterans had a 29% higher overall death rate than those who did not serve in Vietnam. Interestingly, the excess was due mainly to an increased rate among Vietnam veterans in the Engineer Corps (rate ratio=2.5). In addition to an overall elevated death rate, Vietnam veterans had increased death rates for digestive system diseases, diseases of the circulatory system and external causes. The death rates from neoplasms (all types combined) were similar in the two groups.[10]

1.3. RATIONALE AND RESEARCH QUESTIONS

Aside from the obvious importance of studying premature deaths because of the human tragedy they represent, there are several methodologic reasons why a detailed study of mortality is essential in a comprehensive evaluation of the health consequences of military service in Vietnam. First, death is an objective health outcome, not subject to some of the potential biases of self-reported health information. Second, the prevalence of certain health outcomes can be assessed accurately only if deaths due to them are included in the analysis. For example, a sizeable proportion of people with cardiovascular diseases and certain cancers die within a short time after the onset of the disease, as do those with very serious intentional or unintentional injuries, thus becoming unavailable for interview or examination in a subsequent study. This would lead to a serious underestimation of rates for such conditions in a retrospective study, unless mortality is included. Finally, a study of mortality may be the only feasible mechanism for continued surveillance of the study cohort after the current VES ends. This is critical for serious health effects which may first become manifest more than 15 years after service in Vietnam.

At the time the VES was conceived, the research objective was simply to examine the relationship between Vietnam service and deaths from all causes combined as well as specific causes of death. This objective stemmed from the rationale that the "Vietnam Experience" was a generic term for a wide range of health-influencing exposures operating among those who served in the military in Vietnam. Included in the "experience" are known exposures, such as the psychological stresses of war, possible exposure to various infectious diseases prevalent in Vietnam, possible misuse of drugs and alcohol, and possible exposure to the defoliant Agent Orange, as well as many unknown exposures. These factors are unmeasured in this study; therefore, it is not possible to examine directly their relation to mortality. However, based on the observed patterns of mortality, speculation on the possible influence of one component relative to the others may be possible.

As a result of the recently reported findings from the mortality studies of Vietnam-era veterans reviewed above, special attention will be focused on the relationship of Vietnam service to deaths from external causes, specifically, motor vehicle accidents, suicide and other external causes of death. Moreover, the risk of death associated with Vietnam service will be examined in various subgroups, particularly type of unit and military occupational specialty. Although previous studies suggest a relationship between service in Vietnam and several natural causes of death, for example, soft-tissue cancers, the numbers of these deaths expected in our cohort are too few to address these questions adequately.

2. STUDY GROUP DEFINITION, DATA COLLECTION, AND FOLLOW-UP

The present study employs a historical cohort design to evaluate the rate of death among U.S. Army veterans who served in Vietnam relative to a comparison cohort of Army veterans who served during the same time period but not in Vietnam. This type of study involved identifying a cohort of Vietnam-era veterans, determining those veterans who died after discharge from active duty, and collecting detailed information on the nature and circumstances of each death.

2.1. CRITERIA FOR INCLUSION

The primary objective in defining the study and reference groups was to obtain two cohorts that were as similar as possible with regard to major health-influencing factors other than Vietnam service. Achieving this objective does not result in a representative sample of all military personnel who served in Vietnam. Comparability, however, was considered of paramount importance to increase the likelihood that any differences between the cohorts in mortality or morbidity after discharge was the result of service in Vietnam rather than the result of differences in preexisting health-related factors. To achieve this objective, only veterans meeting the following criteria were included in the study:

a) ***U.S. Army veterans.*** The majority of military personnel who served in Vietnam were in the Army. Air Force and Navy personnel involved in the conflict were often stationed in various other parts of Southeast Asia near Vietnam. Marine Corps personnel were deployed in ways very similar to Army troops but in smaller numbers, and a very high proportion of all Marine Corps personnel of the Vietnam era spent time in Vietnam, thus making it difficult to find an adequately large comparison group of Marines without experience in Vietnam.

b) ***Male veterans.*** On the basis of the sample size and selection process described below, too few women would be included for any meaningful conclusions to be drawn regarding the health of female Vietnam veterans.

c) ***Military occupational specialty (MOS) other than "duty soldier" and "trainee."*** During the early stages of the study, we found that men with behavior or conduct problems were given the military occupational specialty of "duty soldier" (MOS 57A10). The probability of assignment to Vietnam for someone with this MOS may have been based more on the personal characteristics of the individual than on his specific training. A military occupational speciality of trainee (09B00) indicates that the individual never left basic or advanced training in the United States.

d) ***Single term of enlistment in the Army.*** Veterans who reenlisted may be very different in background characteristics from those not choosing to do so. Further, reenlistment carried with it more opportunity to serve in the country of one's choice. Again, these characteristics may be associated with subsequent health. It should be noted that because of the method of sample selection, men who subsequently entered another branch of the military could be included in the cohort.

e) ***Minimum of 16 weeks of active service time.*** Army regulations stated that servicemen could not be sent to duty stations such as Vietnam until they had completed at least 16 weeks of active service time.[11]

f) ***Pay grade E-1 to E-5 at discharge.*** In many combat specialties the vast majority of career soldiers had at least one tour of duty in Vietnam, making it difficult to identify a comparison group of their peers who did not have Vietnam service.

g) ***Entered military service for the first time between January 1, 1965, and December 31, 1971.*** This corresponds to the period when a substantial number of single-term volunteer or drafted soldiers were assigned to duty in Vietnam. Before and after this

period, the majority of servicemen in Vietnam were advisors (career enlisted men and officers), who were few in number and who are disqualified for one or more of the reasons given above.

h) ***Duty stations for men in the comparison group limited to the United States, Germany, and Korea.*** On the basis of a pretest conducted by CDC in May of 1983, the vast majority of draftees and single-term volunteers who did not serve in Vietnam were assigned to these locations. More importantly, it was felt that the assignment process for other foreign countries worked differently than for the U.S., Germany, and Korea. Therefore, those who served elsewhere may be quite different in their background characteristics from those who served in Vietnam, Germany, Korea, and the United States.

2.2. SAMPLE SIZE AND POWER

The VES was designed principally to assess morbidity associated with service in Vietnam; mortality is being examined for the reasons described in Section 1.3. Power computations for the health interview phase suggested that a sample size of 6000 for each cohort was necessary to detect a relative risk of 2.0 for conditions that occur with a prevalence of 5/1000 or greater in the unexposed population (assuming the probabilities of Type I and Type II errors are 0.05).[3] To obtain 6,000 completed interviews in both the Vietnam and non-Vietnam groups, the starting sample size had to account for the possibility of an estimated 15 percent non-location rate and a 15 percent interview refusal rate. Thus, the minimum number of veterans to be selected for each cohort was estimated to be 8300 (i.e., 8,300 x 0.85 x 0.85).

Given about 8,500 servicemen in each of the two cohorts, the minimum detectable relative risks for overall mortality and selected causes of death are presented in Table 1. Adequate power exists to detect as statistically significant moderate increases in overall mortality and certain common causes of death. For example, the study has 95 percent power to detect a relative risk of 1.3 for overall mortality and 1.5 for deaths due to accidents. The study has good power to detect moderate increases in risk of suicide, circulatory disease, and malignant

Table 1. Smallest Relative Risks Detectable with 95% Power for Selected Causes of Death*

Cause of death	Deaths+ /1000	Rate ratio++
All causes	35.5	1.3
Accidents	13.2	1.5
Homicide	4.6	2.0
Suicide	4.3	2.0
Diseases of heart	3.1	2.3
Malignant neoplasms	2.9	2.3
Cirrhosis of liver	1.1	3.5
Cerebrovascular diseases	0.6	4.9

*Adapted from 1983 CDC Protocol[3] (Table 1, p. 43)

+ Expected deaths over 17 years (1968–1984) based on 1978 U.S. age-specific rates for males as applied to a hypothetical cohort of men aged 22 at initiation of follow-up.

++ Vietnam cohort relative to non-Vietnam cohort, with 8500 in each cohort. Calculated by Arc Sin approximation, alpha = 0.05 (two-sided).

neoplasms. The study's power to detect relative increases for less frequent causes of death is limited unless a large risk is associated with Vietnam service. Additionally, the study has reasonable power to detect differences in risk for total mortality in certain subgroups of veterans. For example, if only 10% of veterans are in a subgroup of interest, a minimum relative risk of 2.0 can be detected for all causes.

2.3. SELECTION OF VETERANS

Vietnam-era veterans were randomly selected from a set of computer tapes containing "accession numbers," each of which refers to a unique military personnel record on file at the National Personnel Records Center (NPRC) in St. Louis, Missouri. NPRC supplied CDC with a restricted range of approximately five million accession numbers for U.S. Army veterans whose service records were received by NPRC between September 1964 and June 1977. NPRC estimated that the vast majority of discharged U.S. Army Vietnam-era veterans would be included in this set.

From a pilot test conducted in September 1983, it was estimated that approximately 40% of Army veterans randomly selected from the NPRC files would meet the eligibility criteria outlined above and that approximately half of these would have served in Vietnam. Thus, to identify 16,000 to 17,000 qualified veterans, the required starting sample size was approximately 43,000 veterans.

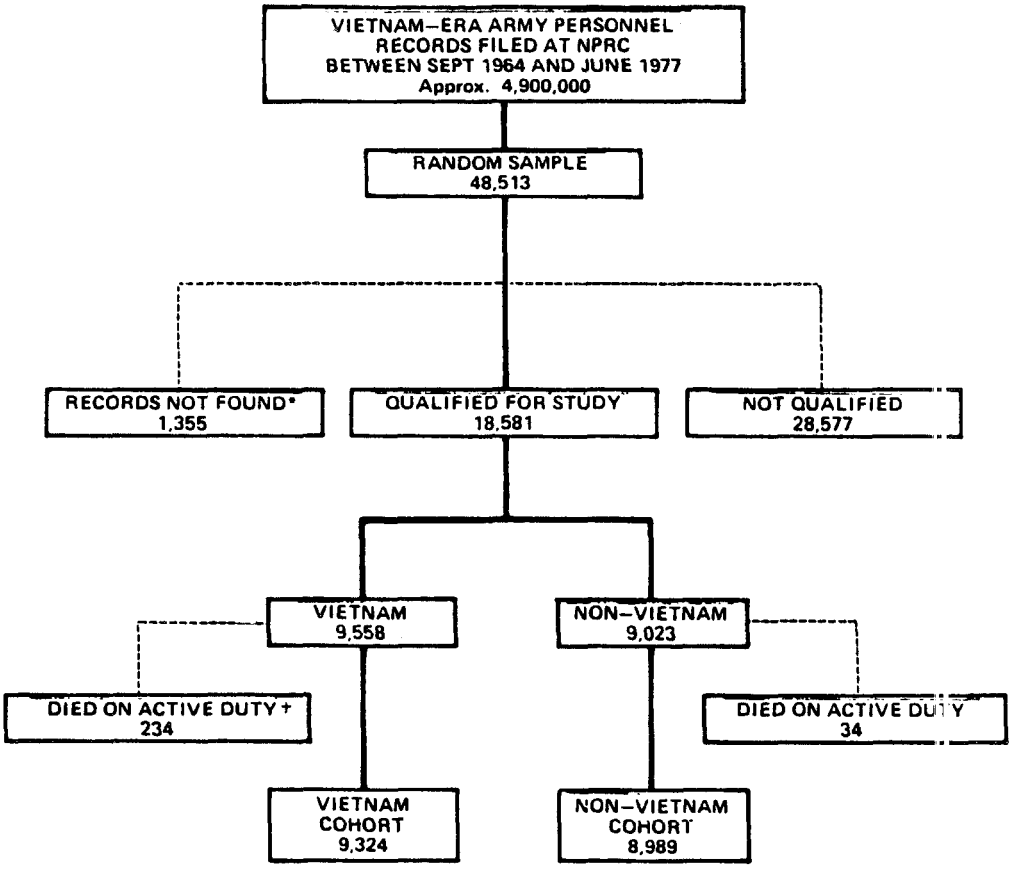
A random number generating program was used to select the sample of approximately 43,000 accession numbers from this universe. The sample was split into 12 equal random samples for ease of processing. The decision to disqualify short-term men (less than 16 weeks of active service time), trainees, and "duty soldiers" was made after the original sample had been drawn. In order to make up for these losses, we added two additional random samples of approximately 3,500 each to the list originally drawn. Personnel records corresponding to these numbers were pulled and reviewed for the inclusion criteria listed above.

As outlined in Figure 1, 99% (N=48,513) of the random numbers generated corresponded to a unique accession number on the NPRC computer tapes. Of these, 1,355 referred to records that could not be located after several attempts. Apparently, many of these were missing because of a subsequent reenlistment after an earlier discharge. Of the 47,158 veterans whose records were located and reviewed, 61% were excluded because they failed to meet one or more of the inclusion criteria outlined above, but less than 1% were excluded because information necessary to determine study eligibility or to categorize them with respect to critical factors, such as duty station, was missing. Thus, 18,581 men qualified for the study (9,558 Vietnam and 9,023 non-Vietnam veterans).

2.4. COLLECTION OF DATA FROM MILITARY PERSONNEL FILES

Each month for 14 consecutive months, lists containing 3,500 accession numbers were sent to NPRC. NPRC located the corresponding military records (201 files) and sent them to the Army Reserve Personnel Center, formerly known as the Reserve Component Personnel and Administration Center (RCPAC), also located in St. Louis, Missouri. Each file was reviewed there for certain eligibility criteria, and a data abstraction form was initiated. Data abstraction forms and files of veterans who appeared to meet the criteria for the study were forwarded to the U.S. Army and Joint Services Environmental Support Group (ESG) in Washington, D.C., where a second qualification process was completed. Detailed information was then abstracted from the files of those veterans found to be qualified for the study. A majority of the data for the study were taken from the Department of Defense Form 214 and Department of the Army Form 20. All data abstraction forms were then sent to CDC for keying and editing.

FIGURE 1. Selection of Study Group



* Excluded from study.

+ Eighty-three percent (N = 194) of active duty deaths among Vietnam veterans were due to war-related activities.

Information abstracted from the personnel files can be grouped into two types. The first type consists of data collected at time of entry into the Army. Variables include demographics, such as date of birth, race, and birthplace, and preservice characteristics, such as physical and mental health as determined by the entrance physical examination, and measures of general intelligence and aptitude.

The second type of characteristics abstracted from the military personnel records describes the veteran's military experience. These include the date of entry, location and dates of each tour of duty, types of units, military occupational specialty during each tour, total length of active military service, indications of misconduct, date of separation from active duty, and type of discharge (character of service). A more detailed description of entry and military history characteristics is presented in Appendix A. Finally, names and addresses of next-of-kin were abstracted for use in locating living veterans for the health interview and examination phases of the study.

Military records of veterans ascertained to have died after discharge were independently rereviewed to verify that duty stations had been accurately recorded. All of them were found to have been correctly classified as "Vietnam" or "non-Vietnam" in the initial abstraction process.

2.5. VITAL STATUS ASCERTAINMENT

Although men were identified by date of entry into the Army, this report examines mortality after separation from active duty. Follow-up began the day the veteran was separated from active service and terminated on the date of his death or December 31, 1983, whichever came first. Follow-up was terminated at the end of 1983 because identification of deaths from the various tracing sources after that date was not complete. Veterans who died on active duty are excluded from the study but some data on them are given here for completeness.

2.5.1. Inservice Deaths

Inservice deaths were identified during the review of military personnel files to determine study eligibility. Any veteran who died during active military service, regardless of the manner or circumstances of his death, has a "casualty report" (Form 1300) placed in his military personnel file. This process was necessary to remove the decedent from the active military rolls as well as to activate payment of benefits to his survivors.

Table 2 presents the numbers of inservice deaths by the manner of death. Overall, 234 (2.4%) of Vietnam veterans were found to have died during active service, but only 34 (1.4%) of the comparison group had died in service. The possible effect of this disproportionate depletion of the cohorts on the postservice mortality experience is examined later.

Table 2. Number of Deaths During Active Military Service Among Vietnam and Non-Vietnam Veterans, by Manner of Death

Manner of death	Vietnam		Non-Vietnam	
	No.	(%)	No.	(%)
Hostility related	181	(77.3)	0	(0.0)
Implements of war related	13	(5.6)	1	(2.9)
Other	35	(15.0)	33	(97.1)
Unknown	5	(2.1)	0	(0.0)
Total	234	(100.0)	34	(100.0)

The narrative summary from the casualty report, which described the manner and circumstances of death, was used to place inservice deaths in respective categories. A "hostility-related" death is defined as one resulting from direct or indirect contact with hostile enemy action. The "implements of war-related" death category includes deaths not directly or indirectly related to enemy action, but from the operations or implements of war, such as "killed by friendly fire." Finally, an "other" category includes deaths not related to war operations or to enemy action, such as those from motor vehicle accidents, drownings, and natural causes.

The majority of inservice deaths among Vietnam veterans was due to hostility-related causes. The rates of inservice deaths not due to war-related activities are identical in the two cohorts (i.e., 3.7 deaths per 1,000).

Although not shown, only 3 of the 68 deaths assigned to the "other" cause of death category were due to natural causes. All three are among Vietnam veterans and their causes are malaria (ICD-9, 84.0), malignant neoplasm of connective or soft tissue (ICD-9,171.9), and unknown or unspecified cause (ICD-9,799.9). The remaining deaths in the "other" category were due to external causes, with a majority of these attributed to motor-vehicle accidents (11 Vietnam and 19 non-Vietnam).

2.5.2. Postservice Deaths

Deaths occurring after separation from active duty were identified with the assistance of several Federal agencies. Computer tapes containing the names, social security numbers, and dates of birth of all veterans not known to have died in service were submitted simultaneously to the following agencies:

- Veterans Administration - Beneficiary Identification and Record Locator Subsystem (BIRLS)
- Social Security Administration
- Internal Revenue Service (through special arrangement with the National Institute for Occupational Safety and Health)
- National Center for Health Statistics (NCHS) - National Death Index

Each of these agencies receives notifications (in different degrees of completeness) of deaths and maintains this information in computer-based files. In addition to these, two other sources were used to identify postservice deaths. The first is the "casualty report" described previously, which is also filed for any veteran who dies while in reserve status, a period of up to 4 years following date of separation from active duty for draftees and up to 3 years for volunteers. It is also filed for those veterans who are currently receiving military benefits at the time of death.

The second additional source of postservice deaths was the locating and contacting procedures used for the health interview component of the VES. Names of next-of-kin and address information obtained from military personnel files and the various Federal agencies were used to locate veterans not identified as deceased by other sources. Several mechanisms were used to ascertain their present address and telephone number, including Directory Assistance telephone tracing, credit bureau checks, local directories, and contacts with relatives and neighbors. All tracing and follow-up activities were done by persons who had no knowledge of the veterans' military background, including countries of service. Four percent of all postservice deaths were identified solely through these means.

As shown in Table 3, confirmation of vital status was finally established for 93.6% of the Vietnam cohort and 91.9% of the non-Vietnam cohort. Since the proportion of veterans with uncertain vital status was small and similar for the two cohorts, these men were considered alive at the end of follow-up for analytic purposes.

Table 3. Vital Status of Vietnam and Non-Vietnam Veterans at End of Follow-up (December 31, 1983)

Vital status	Vietnam		Non-Vietnam	
	No.	(%)	No.	(%)
Known dead*	246	(2.6)	200	(2.2)
Known alive	8,488	(91.0)	8,067	(89.7)
Status uncertain	590	(6.3)	722	(8.0)
Total	9,324	(100.0)	8,989	(100.0)

*Includes 9 veterans (7 Vietnam and 2 non-Vietnam) for whom death certificates were not recovered but for whom sufficient information was obtained to be certain that they had died.

2.6. DETERMINATION OF CAUSE OF DEATH

For veterans who died during the follow-up period, a copy of their death certificate was obtained from the appropriate state or local vital statistics office. Successful retrieval of death certificates was achieved for all but nine deaths. Underlying cause and contributing causes of death were determined from the death certificate by an experienced nosologist and, independently, by a panel of physicians using all available supplemental medical and law enforcement information.

2.6.1 Death Certificates

Underlying causes of death were determined and coded by an experienced nosologist at the National Center for Health Statistics. Causes of death were coded to both the Eighth and Ninth revisions of the International Classification of Diseases.[12,13] The Eighth Revision was used when the mortality experience of Vietnam and non-Vietnam veterans was compared with that of the U.S. general male population, and the Ninth Revision was used when the mortality of Vietnam veterans was compared directly to that of non-Vietnam veterans. The nosologist had no knowledge of whether the decedent had served in Vietnam.

The reproducibility of the cause-of-death coding was examined through a blind resubmission to the nosologist of a 10% random sample of deaths due to external causes and a 10% sample coded to nonexternal causes. There was 98% agreement between initial and repeat cause-of-death codes.

2.6.2. Medical Review Panel - Supplementary Records

To provide an assessment of the cause of death independent of the one given on the death certificate, a special review was undertaken by a medical panel consisting of two physicians and a registered nurse. The nurse used the death certificate information to obtain pertinent medical and legal documentation describing the nature and circumstances of each death. Sources for record retrieval included hospitals, law enforcement agencies, coroners or medical examiners, and private physicians. For each death, any source that was deemed important for determining the nature and circumstance of the death, with the exception of interviews with next-of-kin, was pursued. Next-of-kin were contacted only when their permission was required for release of medical records. Only deaths for which *all* available records were successfully retrieved were reviewed. The nurse synthesized the available information into a summary statement which also indicated the sources and availability of pertinent records.

Before meetings of the medical review panel, the case summaries were reviewed by the two physicians, and each independently assigned an underlying cause of death. The physicians were not aware of the place of military service and the death certificate cause of death. Significant diseases known to be present at the time of death were listed as "other significant conditions." For external causes of death they judged the intentionality and manner of death (accident, suicide, homicide, undetermined).

One physician was assigned as "primary reviewer" for each death and reported his determination of the underlying cause of death, other significant conditions, and manner of death as well his rationale. If the other panelist disagreed, the evidence and reasoning in support of each point of view was presented. Additional information could be requested from the nurse, and final resolution of the disagreement was occasionally deferred until a subsequent medical panel meeting, held after the case had been reviewed by outside experts in the fields of forensic pathology and nosology. A cause of death was assigned only after a consensus was reached. All causes of death and other significant conditions were coded according to the Ninth Revision of the International Classification of Diseases.

3. METHODS OF ANALYSIS

3.1. DEFINITION OF CRITICAL VARIABLES

3.1.1. Place of Service

To be included in the subgroup of *Vietnam veterans*, an individual had to have served in Vietnam any time during his term of enlistment. Although the normal maximum tour in Vietnam was designated by the Army as 12 months[11], no minimum time was placed on the actual number of months a veteran had to have served in Vietnam to be included in the study. For example, if a veteran was wounded in Vietnam, having served only 4 months of his 12-month tour, he was still included in the Vietnam cohort. A small number of men managed to serve two terms of duty in Vietnam within their term of enlistment. A *non-Vietnam veteran* had to have served at least one tour of duty in Germany, Korea, or the United States and to have never served in the Army in Vietnam.

Most comparisons presented here are between veterans who served in Vietnam and those who served elsewhere. Analyses using veterans who served only in the United States or in Germany or Korea as the comparison group are not presented unless they help elucidate a particular finding observed with all non-Vietnam veterans.

3.1.2. Covariates

Table 4 presents a list of all covariates considered and their categorizations used in the analysis. All were obtained from veterans' military personnel files. Several of the variables need an explanation:

- *PULHES*. The term PULHES is an acronym for six categories that describe the physical and mental health of the veteran at entry into the service. The categories are physical capacity or stamina, upper extremities, lower extremities, hearing and ears, eyes and visual acuity, and psychiatric functioning. Each category was rated on a four-point scale, ranging from a score of one, indicating no impairment, to a score of four, indicating maximum impairment, which was below Army retention standards.[14]
- *Composite Measure of Physical/Psychological Functioning*. This represents a summary measure of the PULHES results. The veteran was given an overall rating of physical and psychological health based on his separate ratings in the six categories of the PULHES. Any impairment on one or more of the individual components would result in a rating of some impairment on the summary measure. For analytic purposes, the composite measure was dichotomized into "no impairment" and anything other than no impairment. This composite rating was used to determine eligibility for military service as well as eligibility for specific military occupational specialties. In controlling for preservice health, the composite index, rather than the components of the PULHES, was used.
- *Army Classification Battery*. This is a series of aptitude tests given at entry into the service to aid in assigning a military occupational specialty. The battery consisted of five separate tests, each measuring a different area of aptitude. The areas are verbal ability, arithmetic reasoning, general information, general technical, and pattern analysis. The tests were scored numerically, and the possible range of scores was from 0 to 200. Scores on the various components were highly correlated. Of the five tests, the general technical (GT) test was considered to be the best single test for indicating aptitude.
- *Armed Forces Qualification Test (AFQT)*. This is an aptitude test that served two functions: 1) to determine whether the individual met the minimum qualification criteria for

military service, and 2) if qualification criteria were met, to aid in the placing of individuals in military occupational specialties. This test was numerically scored with a possible range of scores from 0 to 100.

— *Military Occupational Specialty (MOS).* This describes the job or jobs for which the veteran was trained or the one(s) he actually held while in the Army. Assignment of "primary" MOS was based on an individual's civilian education and other training and work experience, as well as on his performance on Army aptitude tests.[15] For the purpose of this analysis all MOSs were divided into two broad categories, "tactical" and "all others." Tactical includes infantrymen, armored vehicle crewmen, combat engineers, and artillery crewmen.[16] (A more detailed distribution of MOS is provided in Appendix A, Table 4.) When considering the possible confounding effects of MOS, we used the MOS for which the veteran was trained (Primary MOS). When the potential modifying effect of MOS was examined, the job the veteran actually held (Duty MOS) was used.

Table 4. Covariates Considered and Associated Categorizations Employed in the Analysis

Variable	Categories for analysis*
Race	White, Nonwhite
Place of birth	Northeast, Midwest, South, West+
Enlistment status	Volunteer, Draftee
PULHES categories:	
Physical capacity or stamina	No Impairment, Some Impairment
Upper extremities	No Impairment, Some Impairment
Lower extremities	No Impairment, Some Impairment
Hearing acuity and ears	No Impairment, Some Impairment
Eyes and visual acuity	No Impairment, Some Impairment
Psychiatric functioning	No Impairment, Some Impairment
Composite index of physical and psychological health	No Impairment, Some Impairment
Army Classification Battery:	
Verbal ability	Continuous measure; range from 1–200
Arithmetic reasoning	Continuous measure; range from 1–200
Pattern analysis	Continuous measure; range from 1–200
General information	Continuous measure; range from 1–200
General technical (GT)	Continuous measure; range from 1–200
Armed Forces Qualification Test (AFQT)	Continuous measure; range from 1–100
Military occupational specialty (MOS)	Tactical, Other
Type of unit	Infantry, Engineer, Armor, Cavalry, Artillery, Other
Months of active duty	0–11, 12–23, 24+
AWOL or confinement time	Ever, Never
Type of discharge	Honorable, Nonhonorable
Pay grade at discharge	E1–E3, E4–E5
Age at discharge from active duty	<21, 21+ years++
Year of discharge from active duty	Before 1970, 1970 and later

*Unknown values excluded from analyses.
+Foreign places of birth included with West category.
++When rate ratios are adjusted for age at separation, age is treated as a continuous variable.

Potential confounders in this study are primarily variables measured before service (entry characteristics). Characteristics measured during service or at discharge have the potential of being part of the "Vietnam experience", and controlling for them may alter the effect of Vietnam service. However, certain military service characteristics examined in this study pay grade at discharge, type of discharge, and absence without official leave (AWOL) or confinement time) could also be associated with background characteristics. Since the role of these factors is unclear and prior studies suggest that at least one of them (pay grade) is an important predictor of mortality[17], both their possible modifying and confounding potential were examined.

3.1.3. Cause-of-Death Categorization

Each of the 15 major subgroups of the International Classification of Diseases, Ninth Revision was examined, with the exception of the groups pertaining to complications of pregnancy and childbirth and to conditions originating in the perinatal period. Neither was applicable to the study population.

Because we anticipated that the majority of deaths would be attributed to external causes, a more detailed breakdown of external causes of death (shown in Table 5), was examined. The categorization includes deaths due to motor-vehicle accidents, accidental poisonings, suicides, homicide, injury of undetermined intentionality, and a category of all other external causes.

Table 5. External Cause-of-Death Subcategories and Associated ICD-9 Codes Used in Mortality Analyses

Sub-category	ICD-9 codes	Specific causes
1. Motor vehicle accident	E810–825, E929.0	Motor vehicle traffic & nontraffic accidents; Late effects of motor vehicle accidents
2. Accidental poisoning	E850–869, E929.2	Accidental overdose of drugs; poisoning by solids, liquids, gases & vapors; Late effects of accidental poisoning
3. Suicide	E950–959	
4. Homicide	E960–969	
5. Injury of undetermined intentionality	E980–989	Injuries undetermined whether accidentally or purposely inflicted
6. Other external causes	E800–807, E826–849	Railway accidents; Recreational vehicle, water transport and air transport accidents
	E870–879	Surgical and medical misadventures and complications
	E880–888	Accidental falls
	E890–899	Accidental fires and flames
	E900–909	Accidents from natural & environmental factors
	E910–915	Submersion & suffocation
	E916–928	Other accidents
	E929.1, E929.3–929.9	Late effects of the above accidents
	E930–949	Adverse effects of drugs in therapeutic use
	E970–978	Legal intervention

Because of the expected underascertainment of suicide on the basis of death certificates and the potential for the underascertainment to be different for Vietnam than for non-Vietnam veterans, a broader definition was also examined. This includes accidental poisonings (E850-E869, E929.2), recorded suicides (E950-E959), injuries of undetermined intentionality (E980-E989), and unknown cause of death (799.9).[18]

There is no comprehensive classification of alcohol or drug-related deaths in the ICD-9 nomenclature. Rather, alcohol-specific and drug-specific conditions are contained within various ICD-9 categories. For example, alcohol-dependence syndrome is included in the category of mental disorders and alcoholic liver disease, in the digestive system category. For estimating the extent of substance abuse in this study, special categories of alcohol- and drug-related deaths were developed. These are shown in Tables 6 and 7.

Alcohol-related deaths encompass three categories:

(1) Nontraumatic deaths in which either the underlying cause or a contributing cause is an alcohol-specific medical, neurologic, or psychiatric disease.

(2) Deaths attributed to accidental poisoning by alcohol and other accidental deaths in which a contributing cause was nondependent abuse of alcohol or excessive blood level of alcohol. Excessive blood level of alcohol is not defined quantitatively in the ICD-9 manual. Although NCHS policy is to code as "excessive blood alcohol" (ICD-9, 790.3) any citation on the death certificate of a blood alcohol concentration greater than zero, the medical review panel definition was a blood alcohol concentration greater than or equal to 100 mg%.

(3) Deaths due to suicide, homicide, or injury of undetermined intentionality with a contributing cause of nondependent abuse of alcohol or excessive blood level of alcohol.

Drug-related deaths included deaths with an underlying or contributing cause of drug dependence or nondependent abuse of drugs other than alcohol or tobacco, deaths due to accidental poisoning by drugs, suicide where the mode of death was drugs, and deaths with intentionality undetermined but where the mode was drugs.

Table 6. Alcohol-Related Deaths Based on ICD–9 Diagnoses Cited as Either Underlying or Contributing Causes of Death

Disease category	Underlying cause	Contributing cause
Medical, neurologic and psychiatric	Alcoholic psychoses (291.0–291.9) Alcohol dependence syndrome (303) Nondependent abuse of alcohol (305.0) Alcoholic polyneuropathy (357.5) Alcoholic cardiomyopathy (425.5) Alcoholic gastritis (535.3) Alcoholic liver disease (571.0–571.3) Excessive blood level of alcohol (790.3)	
Accidents (Unintended trauma)	Accidental poisoning by alcohol (E860.0–E860.9)	
	Any other accident	Nondependent abuse of alcohol (305.0) or Excessive blood level of alcohol (790.3)
Other trauma	Suicide, homicide or injury of undetermined intentionality	Nondependent abuse of alcohol (305.0) or Excessive blood level of alcohol (790.3)

Table 7. Drug-Related Deaths Based on ICD-9 Diagnoses Cited as Either Underlying or Contributing Causes of Death

Disease category	Underlying cause	Contributing cause
Drug dependence and abuse	Drug psychoses (292.0–292.9) Drug dependence (304.0–304.9) or Nondependent abuse of drugs other than alcohol or tobacco (305.2–305.9)	
	Any other natural cause or any traumatic cause except accidental poisoning by a drug of abuse*, Suicide by drugs or poisoning by drugs of undetermined intentionality	Drug dependence (304.0–304.9) or Nondependent abuse of drugs other than alcohol or tobacco (305.2–305.9)
Accidental poisoning of drugs	Accidental poisoning by a drug of abuse*	Accidental poisoning by a drug of abuse*
Suicide by drugs or poisoning by drugs, intentionality undetermined	Suicide by drugs (E950.0–E950.5) or Poisoning by drugs, intentionality undetermined (E980.0–E980.5)	Suicide by drugs (E950.0–E950.5) or Poisoning by drugs, intentionality undetermined (E980.0–E980.5)

* Includes the following drug categories:
Opiates and related narcotics (E850.0)
Salicylates (E850.1)
Aromatic analgesics, not elsewhere classified (E850.2)
Other non-narcotic analgesics (E850.5)
Other analgesics, antipyretics and antirheumatics (850.8)
Barbiturates (E851)
Sedatives and hypnotics (E852.0–E852.9)
Tranquilizers (E853.0–E853.9)
Other psychotropic drugs (E854.0–E854.3)
Other central nervous system depressants (E855.1)
Local anesthetics (E855.2)
Glues and adhesives (E866.6)
Nitrogen oxides (E869.0)

3.2. INTERNAL COMPARISONS

The analysis was approached in stages. The first stage addresses the hypotheses under study without adjustment or consideration of any covariates. The second stage of the analysis focuses on the concept of effect modification. This is concerned with identifying subgroups of Vietnam veterans that are at unusually high or low risk. Of particular interest here, in light of the finding for Australian Vietnam veterans, is whether the effect of Vietnam service on subsequent mortality is different for men who served in engineering units compared with other units. The final stage in the analysis determines whether any covariates, alone or in combination, could explain or mask any associations between service in Vietnam and the subsequent likelihood of dying.

The analytic approach used in *stage one* is a simple comparison of the relative frequency of death among Vietnam veterans with the relative frequency among veterans who did not serve in Vietnam. The mortality rates are based on person-years at risk since discharge from active duty. In this study veterans enter follow-up at different points in time, depending on

their dates of separation from active duty. This could potentially affect the distribution of follow-up time for the two cohorts under study. The person-year approach takes into account these differing lengths of follow-up. The person-year approach also assumes a constant death rate over time. If the rate changes appreciably during the follow-up period, rates can be calculated separately for smaller time intervals within which the assumption may be more reasonable. Unadjusted rate ratios (RR) were computed from the crude death rates (Vietnam/non-Vietnam). Ninety-five percent confidence intervals (CI) around the RRs were computed by using the procedures described by Laird and Oliver.[19]

In *stage two*, the exploration of effect modification, we attempted to identify high-risk subgroups that could provide insight into the nature of any Vietnam service-mortality association. All covariates listed in Table 4 were examined for their potential modifying effect by stratifying the data by the various levels of the covariate. Homogeneity of the rate ratios was assessed through chi-square tests for interaction derived from multivariate regression models.[19] The criteria for lack of homogeneity of the rate ratios across the various levels of the modifying factor, which is evidence for possible effect modification, is a chi-square statistic with an associated p-value less than or equal to 0.05.

The objective of the *third stage* of the analysis is to examine confounding. Preservice differences in health-related factors could possibly mask or explain the association between Vietnam and mortality. Since relatively few covariates are measured at entry into the service, all are examined for their potential confounding effects. The influence of a potential confounder was evaluated by fitting a multivariate model that incorporated only that covariate and a term for Vietnam service.

The analytic tool used in stages two and three of the analysis is the Cox regression model, which is often referred to as the proportional hazards model.[20] This technique allows for the adjustment of confounders and the examination of the behavior of effect modifiers. It also accounts for differing periods of follow-up by comparing, for every death, the covariates of the deceased individual with those of individuals who have been followed for a similar period of time. The Cox procedure directly models the rate ratio rather than the absolute rate of mortality, thus avoiding the need to estimate an unknown underlying hazard function. The widely used software package PHGLM provided estimates of the parameters, standard errors, and likelihood ratio tests of hypotheses.[21]

The underlying assumption for the proportional hazards model is that the ratio of hazard functions (death rates) for the two groups (Vietnam and non-Vietnam) is constant over the entire follow-up period. Serious violations of this assumption may result in misleading estimates of the effect of Vietnam service on mortality. For example, if the rate ratio is greater than one at some times and less than one at other times, the estimated parameter would be an average which may falsely indicate no difference in the mortality experience between the two groups. This assumption was checked (Appendix F), and if the effect of Vietnam service on mortality appeared to vary over time, separate models were formed for shorter time periods for which the proportionality assumption appeared more reasonable.

All adjusted rate ratios were obtained from Cox regression models stratified on primary MOS (tactical versus nontactical) and enlistment status and adjusted for other potential confounders.[22] Stratification, instead of adjustment for MOS and enlistment status, is based on *a priori* and empirical knowledge that these factors are important determinants of duty location and mortality. Use of stratification, instead of adjustment, reduces the number of parameters to be estimated which could be important in the cause-specific analysis where there are relatively few deaths. The rate ratio estimated from the stratified model is a valid summary of relative mortality in the two cohorts only if the rate ratios in the strata are similar. The uniformity of the four stratum-specific RRs was checked and is presented in Appendix F.

In the cause-specific analyses, a modification of the above analytic approach was necessary because of the small number of deaths in many of the disease categories. If a category contained less than 10 deaths (Vietnam and non-Vietnam cohorts combined), rate ratios were not computed, and no formal conclusions were drawn about comparative risks in the two cohorts. In addition, a smaller set of covariates were examined for their potential modifying or confounding effects.

Other analytic techniques used include standard chi-square statistics for 2x2 and Rx2 tables and the t-statistic for the difference between two means. Additionally, the "percent agreement" and *kappa* statistic are used to quantify and judge the level of agreement between the medical review cause of death and cause of death from the death certificate. The "percent agreement" is the number of deaths assigned to a particular cause-of-death category by both the medical review panel and the death certificate divided by the total number of deaths assigned to that category by the death certificate. The *kappa* statistic is a measure of inter-rater concordance which corrects for agreement expected by chance alone.[23] We used the following criteria when interpreting the kappa statistic: a kappa greater than 0.75 represents excellent agreement beyond chance, values between 0.40 and 0.75 represent fair to good agreement and values below 0.40 represent poor agreement.[24]

All references to "statistical significance" imply that a particular ratio or difference is statistically different from the null value at the *alpha*=0.05 level, assuming a two-sided test of significance.

3.3. EXTERNAL COMPARISONS

The standardized mortality ratio (SMR) adjusted for age, race, and calendar period was used to compare the death rates among Vietnam and non-Vietnam veterans with the rates in the total U.S. male population. The SMR is the ratio of observed deaths among cohort members to the expected number of deaths based on the U.S. mortality experience. The purpose of comparing the two veteran cohorts to the U.S. male general population is to evaluate the anticipated "healthy veteran effect" for natural causes of death.[25] Since all cohort members were initially selected into Army service on the basis of a certain level of physical fitness, one would expect their subsequent mortality from natural causes to be less than that of the general population, which includes men who do not meet the minimum physical requirements of the Army. This expected deficit should be most pronounced in the time period closest to separation from active duty and might eventually disappear with the passage of time as the veterans age.

The SMR calculations were done by using a software package containing U.S. death rates updated through 1980.[26] Ninety-five percent confidence limits for the SMRs were calculated with the Rothman-Boice programs.[27]

4. RESULTS

This chapter is divided into four sections. In the first section, the preservice and military service characteristics of the Vietnam and non-Vietnam cohorts are examined. This provides an understanding of differences existing at entry into the service and differences that may have developed as a result of military service. The second section examines the all-cause mortality experience of the Vietnam group relative to veterans who served in Germany, Korea and the United States. Presented in the third section are results of the cause-specific mortality analyses, including analyses based on cause of death determined from death certificates and on medical review cause of death. The last section contains the results of comparisons of each cohort with the mortality of men of the same age and race in the U.S. general population in the same time period.

4.1. DISTRIBUTION OF COVARIATES FOR VIETNAM AND NON-VIETNAM VETERANS

Ideally, to determine the increase in mortality associated with service in Vietnam, one would like to compare two groups of veterans who are similar with respect to all factors that could influence mortality, except for service in Vietnam. Because this ideal can rarely be attained, except in experimental situations, it is important at the outset to understand any differences in possible health-influencing factors that may exist between Vietnam veterans and veterans who served elsewhere. Caution needs to be exercised, however, when interpreting the statistical significance of differences between the two groups. The large sample sizes tend to make even small between-cohort differences in these factors "statistically significant."

The characteristics of the two cohorts as determined at entry into the Army and those determined during military service are summarized in Table 8. Appendix A contains the actual distributions of all of the characteristics by cohort, with results of tests of statistical significance of differences for each characteristic.

There is no difference in the racial distribution between the two cohorts, but there are slightly fewer draftees among Vietnam veterans than among non-Vietnam veterans (63.7% versus 65.6%) and more Vietnam veterans entered service before 1969. Of the five physical health components measured at entry, significant differences are noted for two: Vietnam veterans had slightly fewer visual (25.5% versus 28.7%) and hearing (5.6% versus 6.7%) impairments. No difference is seen for the assessment of psychiatric functioning. On the tests of general aptitude taken at entry, the mean scores of Vietnam veterans were slightly but "significantly" lower for all components of the Army Classification Battery, and Vietnam veterans also scored slightly lower on the Armed Forces Qualification Test.

The second section of Table 8 contains the military service characteristics, where differences between the two cohorts are greater. More Vietnam than non-Vietnam veterans were in tactical operations jobs (34.3% versus 27.4%), and more Vietnam veterans (26.6%) were assigned to infantry units than were non-Vietnam veterans (14.6%).

Veterans in the Vietnam cohort tended to stay on active duty slightly longer than other veterans (mean=26.1 months versus 25.3 months). Vietnam veterans had fewer instances of AWOL or other "bad" time (11.6% versus 13.3%) and fewer nonhonorable discharges (2.1% versus 8.9%); they were also less likely to be discharged at lower grades (E1-E3) (11.9% versus 20.2%). These differences will be considered in subsequent analyses.

Table 8. Summary of Differences in Entry and Military-Service Characteristics Between Vietnam and Non-Vietnam Veterans

Characteristic	Vietnam	Non-Vietnam
Race (% white)	86.8	86.5
Region of birth (% NE, MW)	49.3	50.4
Year of entry (% before 1969)	72.1	60.6
Age at entry (mean, in years)	20.3	20.5
Enlistment status (% draftee)	63.7	65.6
Health status at entry (% with some impairment)		
Physical capacity	0.9	1.2
Upper extremity	0.7	0.9
Lower extremity	2.6	2.7
Hearing	5.6	6.7
Visual acuity	25.5	28.7
Psychiatric functioning	0.2	0.2
Overall physical health	32.1	36.0
General Aptitude Tests (mean scores):		
Verbal ability	104.4	106.9
Arithmetic reasoning	101.5	103.8
Pattern analysis	101.7	103.5
General information	100.3	100.8
General technical	103.1	105.5
Armed Forces Qualification	50.4	52.3
Primary MOS (% tactical operations)	34.3	27.4
Type of unit (% infantry)	26.6	14.6
Duration of active duty (mean, in months)	26.1	25.3
AWOL or confinement time (% with some "bad" time)	11.6	13.3
Type of discharge (% nonhonorable)	2.7	8.9
Pay grade at discharge (% E1-E3)	11.5	20.2

4.2. ANALYSIS OF ALL-CAUSE MORTALITY

4.2.1 Crude Results

Table 9 presents the total numbers of deaths, crude mortality rates, and rate ratios comparing Vietnam veterans to veterans who served in Germany, Korea, or the United States. The mean number of years of follow-up was similar for Vietnam (13.7 years) and non-Vietnam veterans (13.5 years). Of the 9,324 Vietnam veterans, 246 died during follow-up, compared with 200 of the 8,989 non-Vietnam veterans. Overall, Vietnam veterans had a 17% excess in postservice all-cause mortality relative to veterans who did not serve in Vietnam. This modest excess is not statistically significant.

Table 10 presents relative mortality by the number of years since discharge from active duty. The excess in the relative death rate appears to be limited to the first 5-year period after discharge, during which Vietnam veterans have a 45% higher mortality rate than non-Vietnam veterans. After the initial 5-year period, there is no difference in the mortality experience between the two cohorts. The test for the time-dependent effect of Vietnam service yields borderline significance ($X^2=3.60$, $p=0.057$), suggesting that the relative mortality of Vietnam veterans in the first 5 years may be different from that seen later.

Figure 2 displays graphically the change over time in the relative mortality rate associated with Vietnam service. The hazard rates among Vietnam veterans remain higher than those for non-Vietnam veterans through year 6 of follow-up. After year 6 the hazard rates are similar.

To determine whether the time-specific increase in mortality among Vietnam veterans is consistent across the two major subgroups of the comparison cohort, separate analyses were done using veterans with other foreign service (Germany or Korea) as one comparison and veterans with service only in the United States as a second comparison. A similar pattern of excess all-cause mortality limited to the first 5 years after discharge was found in both comparisons (Table 11). The excess was somewhat greater with veterans who served only in the United States used for comparison (RR=1.57) than with veterans having other foreign service (RR=1.37).

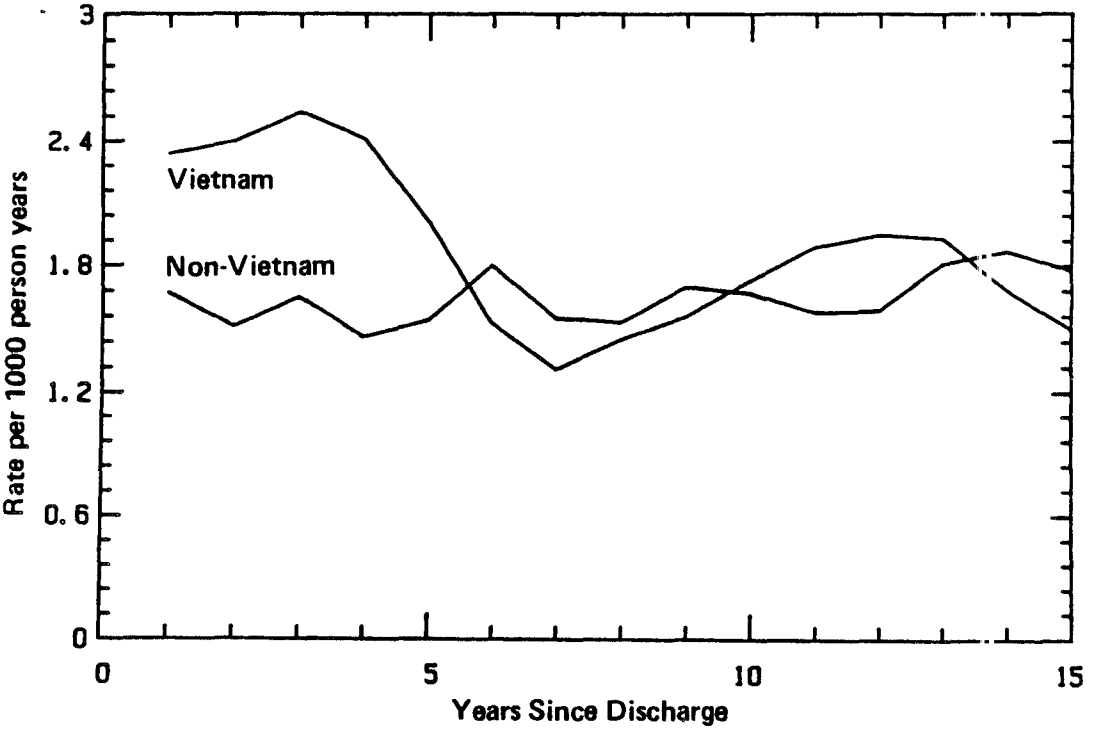
Table 9. Number of Men, Deaths, Person-Years at Risk, and Crude Death Rates/1000 Person-Years Among Vietnam and Non-Vietnam Veterans and Rate Ratios (1965–1983)

	Vietnam		Non-Vietnam
Number of men	9,324		8,989
Number of deaths	246		200
Person-years, postdischarge	127,897		121,330
Crude death rate	1.9		1.7
Rate ratio (95% CI)	1.17	(0.97–1.41)	1.00

Table 10. Number of Deaths, Person-Years, and Crude Death Rates/1000 Person-Years Among Vietnam and Non-Vietnam Veterans and Rate Ratios, by Time Since Discharge (1965–1983)

Years since discharge	Vietnam			Non-Vietnam			Rate ratio	95% CI
	No. deaths	Person-years	Rate/1000	No. deaths	Person-years	Rate/1000		
≤5	110	46,350	2.37	73	44,747	1.63	1.45	1.08 – [illegible]96
6–10	72	45,855	1.57	74	44,233	1.67	0.94	0.68 – [illegible]30
11+	64	35,692	1.79	53	32,350	1.64	1.09	0.76 – [illegible]57
All years	246	127,897	1.92	200	121,329	1.65	1.17	0.97 – [illegible]41

FIGURE 2. Mortality Rates* of Vietnam and Non-Vietnam Veterans, by Years Since Discharge



* Mortality rates are three-year moving averages.

Table 11. Number of Deaths, Person-Years, and Crude Death Rates/1000 Person-Years Among Vietnam Veterans, Veterans with Other Foreign Service (Germany or Korea), and Veterans with No Foreign Service and Rate Ratios, by Time Since Discharge (1965–1983)

Cohort	Years since discharge	No. deaths	Person-years	Rate/1000	Rate ratio	95% CI
Vietnam	≤5	110	46,350	2.4	–	–
	6–10	72	45,855	1.6	–	–
	11+	64	35,692	1.8	–	–
	All years	246	127,897	1.9	–	–
Germany/ Korea	≤5	44	25,485	1.7	1.37*	0.97 – 1.95
	6–10	47	25,210	1.9	0.84	0.58 – 1.22
	11+	31	18,381	1.7	1.06	0.69 – 1.63
	All years	122	69,076	1.8	1.08	0.88 – 1.35
United States service only	≤5	29	19,262	1.5	1.57+	1.05 – 2.37
	6–10	27	19,023	1.4	1.11	0.71 – 1.72
	11+	22	13,969	1.6	1.14	0.70 – 1.85
	All years	78	52,254	1.5	1.29	1.00 – 1.66

*Rate ratios for Vietnam veterans are relative to veterans with other foreign service (Germany or Korea)
+Rate ratios for Vietnam veterans are relative to veterans with U.S. service only.

4.2.2. Consideration of Covariates

Because the increased rate of mortality associated with Vietnam service appears to be limited to the first 5 years of follow-up, all covariates are examined with respect to two time periods, ≤5 years and 6+ years. (See Appendix F for an examination of the proportional hazards assumption within these two time periods.) Table 12 presents a summary of the tests for effect modification. (Refer to Appendix B for details.) There is some suggestion that during the first 5 years of follow-up the effect of Vietnam service is modified by general health status at entry (p=0.08), enlistment status (p=0.10) and year of discharge from active duty (p=.06). Among those with a poorer composite index of health at entry, the effect of Vietnam service on mortality is greater (RR=2.12) than among those with better health at entry (RR=1.20). An 80% increase in relative mortality associated with service in Vietnam is apparent among draftees, but only a 10% increase is observed among those who volunteered for the Army. Finally, a twofold increase in mortality was found among Vietnam veterans discharged before 1970 compared with only a 16% increase for those discharged in 1970 or later. In the later follow-up period, pay grade was identified as an effect modifier (p=.02) Although there is heterogeneity in the RRs across the various pay grades, no particular pattern appears to be associated with this heterogeneity. (See Appendix B, Table 13.) For the total follow-up period, only pay grade at discharge was identified as potentially modifying the effect of Vietnam service on the subsequent rate of mortality (p=.02). There is some variation in the RRs for Vietnam service across the various levels of the other covariates in Table 12, but the variation does not represent a statistically significant departure from homogeneity.

Statistical adjustment for each covariate separately has little effect on the estimate of the RR in either postservice period (Table 13) or for the total follow-up period with two exceptions: type of discharge and pay grade at discharge. After adjustment for type of discharge and pay grade, the rate ratios are increased by at least 0.10 in the initial follow-up period and for the total follow-up period.

Table 12. Summary of Results of Chi-Square Tests (p-values) for Effect Modification of Entry and Military Characteristics, by Time Since Discharge (All-Cause Mortality)

Characteristic	Years since discharge		
	≤5 years	6+ years	All years
Race	0.70	0.78	0.89
Age at discharge	0.45	0.15	0.81
Duty MOS	0.84	0.37	0.54
Enlistment status	0.10	0.52	0.14
Region of birth	0.82	0.70	0.97
Composite index of health	0.08	0.38	0.60
GT score	0.92	0.50	0.60
Type of unit	0.77	0.48	0.52
Duration of active duty	0.20	0.81	0.36
AWOL/confinement time	0.14	0.63	0.18
Year of discharge	0.06	0.69	0.43
Type of discharge	0.39	0.78	0.45
Pay grade at discharge	0.78	0.02	0.02

Table 13. Summary of Rate Ratios for Vietnam Service Adjusted for the Specified Characteristic, by Time Since Discharge (All-Cause Mortality)

Characteristic	Years since discharge		
	≤5 years	6+ years	All years
(Unadjusted)	1.45*	1.01	1.17
Race	1.45*	1.00	1.17
Age at discharge	1.51*	1.01	1.19
Primary MOS	1.44*	1.00	1.16
Enlistment status	1.44*	0.99	1.15
Region of birth	1.45*	0.97	1.16
Composite index of health	1.45*	1.00	1.16
GT score	1.42*	0.97	1.13
Type of unit	1.37*	1.00	1.13
Duration of active duty	1.42*	0.95	1.12
AWOL confinement time	1.50*	1.02	1.19
Year of discharge	1.46*	1.00	1.17
Type of discharge	1.59*	1.09	1.28*
Pay grade at discharge	1.66*	1.14	1.32*

*Ninety-five percent confidence interval excludes 1.00.

Confounding was further investigated by including all of the covariates listed in Table 13 in models for the separate time periods. Because of the strong correlation between AWOL/confinement time, type of discharge, and pay grade at discharge, only one was included in the model. Pay grade was chosen because it appeared, in Table 13, to have the strongest influence of the three on the Vietnam-mortality association. This model yielded adjusted rate ratios of 1.53 (95% CI=1.12-2.10) for the early follow-up period, 0.99 (95% CI=0.77-1.28) for the remaining years of follow-up, and 1.18 (95% CI=0.97-1.44) for all years of follow-up.

In addition, a reduced model was formed that incorporated a smaller set of covariates that will be used for adjustment in the cause-specific analyses where the numbers of deaths are considerably smaller. This model included the following variables: age at discharge and race (both well-established predictors of mortality), MOS and enlistment status (*a priori* and possibly empirical predictors of duty location and mortality), GT score and pay grade (empirically the strongest predictors of all-cause mortality of the remaining covariates), and year of discharge. The RRs obtained from the reduced model (Table 14) are roughly of the same magnitude as the unadjusted RRs. Results from the Cox model also indicate that Vietnam service has a greater effect on mortality among those discharged before age 21 compared to those discharged at age 21 or older (p=0.02) and among veterans discharged before 1970 compared to those discharged during 1970 or later (p=0.05).

4.2.3. Influence of Inservice Deaths

As shown in Figure 1, the rate of inservice deaths among Vietnam veterans was more than 6 times the rate among non-Vietnam veterans. The majority of deaths among Vietnam veterans (83%) were a result of war-related activities (Table 2). This unusual inservice mortality experience among Vietnam veterans may have been selective, that is, it may have eliminated either the healthiest or the least healthy members from the cohort. Such an event might bias our estimate of the effect of Vietnam service on postservice mortality. To examine this possibility, we compared the entry characteristics of Vietnam veterans who died in service as a result of hostile enemy action with characteristics of Vietnam veterans who were alive at discharge from active service (Table 15). There are few differences of note. The two groups are similar in terms of race, enlistment status, the ratings on the individual components of the PULHES profile (with the exception of visual acuity and the composite measure of physical health), and scores on all the Army aptitude tests. For visual acuity and the composite physical health measure, those killed by hostile enemy action were less likely to have any impairment on either measure compared with those discharged alive. (See Appendix C for detailed tables.)

To examine this further, we performed a worst case analysis by assuming that those killed by enemy action had survived and that their postservice mortality experience was worse than that of the remaining Vietnam group. For example, if those killed in action had experienced twice the overall postservice death rate of the actual Vietnam study group, the result would be 10 additional deaths in the Vietnam group, and none among non-Vietnam veterans. However, the "new" RR would be essentially the same as the original one (RR=1.19).

4.2.4. Influence of Incomplete Follow-up

As described in Section 2.5, the proportion of veterans with uncertain vital status was small and similar between the two cohorts (less than 9% in both cohorts). Because of this, we assumed that all those with uncertain vital status were alive at close of follow-up. Our assumption would lead to biased rate ratios if the probability of dying among Vietnam veterans with uncertain vital status was different from that of veterans who served elsewhere. By examining the entry and military service characteristics of men with known and uncertain vital status (Table 16), it can be seen that although men with uncertain vital status are very dif-

Table 14. Regression Coefficients, Standard Errors (SE), and Associated P-Values from Reduced Cox Regression Models*, by Time Since Discharge (All-Cause Mortality)

Covariate (category)	Years since discharge											
	≤5 years				6+ years				All years			
	Coeff.	(SE)	RR+	p-value	Coeff.	(SE)	RR	p-value	Coeff.	(SE)	RR	p-value
Cohort (Vietnam/ other)	0.457	(0.155)	1.58	<0.01	0.036	(0.127)	1.04	0.78	0.207	(0.098)	1.23	0.03
Age at discharge (in years)	−0.079	(0.048)		0.10		(0.036)		0.54	−0.015	(0.029)		0.59
Race (white/ other)	−0.227	(0.202)		0.26	−0.588	(0.154)		<0.01	−0.449	(0.122)		<0.01
GT score (in units)	−0.008	(0.004)		<0.06	−0.012	(0.003)		<0.01	−0.010	(0.003)		<0.01
Pay grade (E4-E5/ other)	−0.740	(0.176)		<0.01	−0.664	(0.147)		<0.01	−0.692	(0.113)		<0.01
Year of discharge (<1970/1970+)	−0.056	(0.155)		0.72	−0.276	(0.137)		0.04	.177	(0.102)		0.08

*Model stratified by MOS and enlistment status.
+RR = rate ratio

Table 15. Summary of Entry and Military Service Characteristics For Vietnam Veterans Killed in Service and Those Discharged Alive

Characteristic	Killed in action* (N=181)	Discharged alive (N=9324)
Race (% white)	86.2	86.8
Enlistment status (% draftee)	64.6	63.7
Physical health (% impaired)		
Physical capacity	0.0	0.9
Eyes and vision	11.1	25.5
Hearing and ears	4.4	5.6
Psychological health (% impaired)	0.0	0.2
Aptitude tests:		
GT score (mean)	103.1	104.4
AFQT (mean)	48.4	50.4
Duty MOS (% tactical)	86.2	34.5
Type of unit (% infantry)	70.1	26.6

*Inservice deaths from causes other than hostile enemy action are excluded.

Table 16. Distribution of Selected Characteristics Among Vietnam and Non-Vietnam Veterans, by Vital Status at End of Follow-Up

Characteristic	Vietnam		Non-Vietnam	
	Status uncertain (N=590)	Status certain (N=8734)	Status uncertain (N=722)	Status certain (N=8257)
Race (% nonwhite)	27.5	12.1	27.0	12.1
Enlistment status (% draftees)	56.3	64.2	53.1	66.1
Physical health (% with any impairment)	29.3	32.6	31.6	36.1
GT score (mean)	96.4	103.6	96.6	106.1
Primary MOS (% tactical)	35.9	34.2	29.8	27.2
Discharge status (% nonhonorable)	11.4	2.1	29.9	7.1
Age at discharge (mean)	21.7	22.0	21.5	22.1
Pay grade at discharge (% E1-E3)	31.4	10.2	53.5	17.3

ferent from those with known vital status in the same cohort, the characteristics of the "uncertain status" groups are similar between cohorts. The characteristics associated with uncertain vital status may be linked to a more unstable lifestyle. In particular, men with uncertain vital status are more likely to be non-white, have lower GT scores, and have a nonhonorable discharge and lower pay grade at discharge. Thus, regardless of cohort status, these men may live a more transient existence with few ties to institutions and relatives, making them more difficult to trace. Since several of these characteristics are also strongly related to mortality (see Appendix B), death rates may indeed be higher among these men but, given the similarity in their characteristics between cohorts, it seems unlikely that there would be a different effect of Vietnam service in this group. In any case, we can estimate the possible effect of a differential rate of mortality. For example, if Vietnam veterans with uncertain vital status had twice the death rate of Vietnam veterans with known status and if the two status groups among non-Vietnam veterans had similar rates, the RR would only increase from 1.17 to 1.22. On the other hand, if Vietnam veterans with uncertain status had a much better survival rate (i.e., approximately one-half the death rate of other men), the revised RR would be 1.12. Thus, two extreme situations produce results that are not very different from the original finding.

4.3. ANALYSIS OF CAUSE-SPECIFIC MORTALITY

4.3.1. Cause of Death Based on Death Certificates

Of the 446 veterans identified as deceased in the time period from date of discharge from active duty to December 31, 1983, death certificates were obtained for 437 (98%). For five of the nine deaths for which death certificates were not obtained, casualty reports were available indicating the death occurred while the veteran was on reserve status or receiving veterans benefits. For the remaining four deaths, the location and date of death were available and confirmed through other sources.

Displayed in Table 17 are the numbers of deaths, crude death rates and unadjusted rate ratios comparing Vietnam veterans with non-Vietnam veterans for 11 major ICD-9 cause-of-death groupings. The four major groupings not shown had no deaths assigned to them (diseases of the blood and blood-forming organs; endocrine, metabolic, and nutritional diseases; diseases of the skin; and diseases of the musculoskeletal system). Of the categories shown, only four contained sufficient numbers for formal analysis. For two of these cause-of-death categories, Vietnam veterans appear to be dying at different rates than non-Vietnam veterans: diseases of the circulatory system (51% decrease) and external causes of death (25% increase). In one additional category mortality appears to be different between the two groups, that is, deaths due to genitourinary conditions. However, it is based on only four deaths, too few for formal analysis. Two of these deaths were attributed to urinary tract infection, one to renal disease (unspecified), and one to renal failure, and all were among Vietnam veterans.

Neoplasms: Table 18 shows mortality from neoplasms (all types) among Vietnam veterans relative to non-Vietnam veterans by time since discharge. A nonsignificant decrease in the relative rate of death is seen in both follow-up periods. We also divided the latter time period into smaller units, (6-10 years and 11+ years) to assess risks in the more recent years that would correspond to a longer latent period for these diseases. Only 7 deaths from neoplasms occurred in the 11+ year follow-up period, 2 among Vietnam veterans and 5 among non-Vietnam veterans, suggesting a deficit among Vietnam veterans. In examining the specific types of neoplasms (Table 19), there does not appear to be any site-specific associations with service in Vietnam. The three deaths among Vietnam veterans from neoplasms of uncertain behavior were all due to brain tumors, but the one among non-Vietnam veterans was a bronchial adenoma.

Table 17. Number of Deaths by Cause (from Death Certificate) and Crude Death Rates/100,000 Person-Years Among Vietnam and Non-Vietnam Veterans and Unadjusted Rate Ratios (1965–1983)

Underlying cause of death (ICD-9)*	Vietnam		Non-Vietnam			
	No. deaths	Rate/ 100,000	No. deaths	Rate/ 100,000	Rate ratio+	95% CI
Infectious and parasitic diseases (001–139)	1	0.8	1	0.8	–	–
Neoplasms (140–239)	12	9.4	14	11.5	0.82	0.38–1.76
Mental disorders (290–319)	7	5.5	7	5.8	0.95	0.33–2.70
Diseases of nervous system (320–389)	2	1.6	1	0.8	—	—
Diseases of circulatory system (390–459)	12	9.4	23	19.0	0.49	0.25–0.99
Diseases of respiratory system (460–519)	5	3.9	4	3.3	–	–
Diseases of digestive system (520–579)	5	3.9	3	2.5	–	–
Diseases of genitourinary system (580–611)	4	3.1	0	–	–	–
Congenital anomalies (740–759)	1	0.8	1	0.8	–	–
Symptoms, signs and ill-defined conditions (780–799)	2	1.6	1	0.8	–	–
External causes (E800–E999)	188	147.0	143	117.9	1.25	1.00–1.55
No death certificate	7	–	2	–	–	–

*No deaths were categorized to diseases of blood and blood-forming organs; endocrine, metabolic, or nutritional diseases; diseases of the skin; or diseases of the musculoskeletal system. Therefore, these categories are not shown.

+ If the total number of deaths for a cause-of-death category in both groups combined was less than 10, rate ratios are not shown.

Table 18. Number of Deaths Due to Neoplasms (from Death Certificate) and Crude Death Rates/100,000 Person-Years Among Vietnam and Non-Vietnam Veterans and Rate Ratios, by Time Since Discharge (1965–1983)

Years since discharge	Vietnam		Non-Vietnam		Rate ratio	95% CI
	No. deaths	Rate/ 100,000	No. deaths	Rate/ 100,000		
≤5	5	10.8	6	13.4	0.81	0.25–2.64
6+	7	8.6	8	10.4	0.82	0.30–2.27
All years	12	9.4	14	11.5	0.81	0.38–1.76

Table 19. Number of Deaths Due to Neoplasms (from Death Certificate)* Among Vietnam and Non-Vietnam Veterans, by Type and Site of Neoplasm (1965–1983)

Neoplasm type/site (ICD–9)	Vietnam	Non-Vietnam
Cancer of colon and rectum (153–154)	0	1
Cancer of liver (155)	1	1
Cancer of lung (162)	0	1
Cancer of skin (172–173)	1	2
Cancer of testis (186)	2	2
Cancer of brain (191)	0	1
Hodgkin's disease (201)	0	1
Lymphosarcoma and other malignant neoplasm of lymphoid tissue (200, 202)	1	1
Leukemia (204-208)	3	2
Malignant neoplasms of unspecified site (199)	1	1
Neoplasms of uncertain behavior or nature (235–239)	3	1

*Because of small numbers of deaths in all categories, rates and rate ratios are not presented.

Circulatory system diseases: Table 20 shows that regardless of the time since discharge, there is a deficit of circulatory disease deaths among Vietnam servicemen relative to those not serving in Vietnam. In Table 21, results for specific types of circulatory disease deaths are presented. The deficit among Vietnam veterans does not appear to be limited to any one type of circulatory disease but extends to all major types.

Mental disorders: Although there were too few deaths in each follow-up interval for formal analysis, Vietnam service did not appear to be associated with the likelihood of dying from mental disorders in either time period. All deaths except one in this category were related to abuse of drugs or alcohol. Drug and alcohol-related mortality will be discussed in more detail later in this Section and also in Section 4.3.2.

External causes of death: Table 22 presents mortality from specific types of external causes. Vietnam veterans were more likely than non-Vietnam veterans to die in motor vehicle accidents (MVA), from accidental poisonings, and from injuries that were undetermined whether accidentally or purposely inflicted. Vietnam service does not appear to be associated with deaths from other accidental causes, suicide, or homicide.

There are 13 accidental poisoning deaths among Vietnam veterans and 5 in the non-Vietnam group. Nine Vietnam veterans died from drug intoxication compared with four non-Vietnam veterans. Of the remaining four accidental poisoning deaths among Vietnam veterans, three were due to carbon monoxide poisoning and one to a work-related toxic gas exposure; the other non-Vietnam veteran death was due to poisoning by an unspecified substance.

Deaths undetermined whether accidentally or purposely inflicted among Vietnam veterans include four poisonings, three deaths by shotgun wound to the head (not stated as self-inflicted), and one in a fire. In this same category, there is one death by drowning and another due to narcotic poisoning among non-Vietnam veterans.

Deaths from MVAs, other accidents, suicide, and homicide contain adequate numbers for further exploration (Table 23). Deaths due to MVAs are significantly elevated among Vietnam veterans in the first five years after discharge (RR=1.93). After 5 years, the excess is considerably less, although still somewhat elevated (RR=1.16). No association is seen in either time period for accidental deaths other than those from motor vehicles or poisonings.

For deaths due to suicide, a 72% nonsignificant increase is seen among Vietnam veterans in the initial 5 years of follow-up, but a deficit is seen thereafter. Because of possible inaccuracy in the recording of suicide on death certificates, we broadened the definition to include all accidental poisonings (E850-E869), reported suicides (E950-E959), injuries undetermined whether accidentally or purposely inflicted (E980-E989), and ill-defined and unknown causes of death (799.9). The main difference between the results for this new category and the previous one is the slight, non-significant elevation in risk now seen in the later follow-up period. (RR=1.12). Finally, an early postservice excess is seen for deaths due to homicide but the relative risk drops below 1.0 thereafter. There were no postservice deaths due to war-related injuries.

In Appendix D, the consistency of the association between Vietnam service and deaths due to MVAs and suicide is examined with respect to age at separation, race, duty MOS, enlistment status, GT score, pay grade at discharge, and year of discharge. In general, the RRs are increased in the first 5 years postservice and are close to 1.0 thereafter. There is some nonsignificant variation among the various subgroups, but the overall patterns are similar to what is observed for total mortality.

Drug- and alcohol-related deaths: Twenty-one deaths meet the criteria outlined in Section 3.1.3 for an alcohol-related death (Table 24). Over the entire follow-up period, there is a 27% increase (nonsignificant) in alcohol-related deaths among Vietnam veterans relative to

Table 20. Number of Deaths Due to Circulatory System Diseases (from Death Certificate) and Crude Death Rates/100,000 Person-Years Among Vietnam and Non-Vietnam Veterans and Rate Ratios, by Time Since Discharge (1965–1983)

Years since discharge	Vietnam		Non-Vietnam		Rate ratio	95% CI
	No. deaths	Rate/ 100,000	No. deaths	Rate/ 100,000		
≤5	0	–	5	11.2	–	–
6+	12	14.7	18	23.5	0.63	0.30–1.30
All years	12	9.4	23	19.0	0.49	0.25–0.93

Table 21. Number of Deaths Due to Circulatory System Diseases (from Death Certificate) and Crude Death Rates/100,000 Person-Years Among Vietnam and Non-Vietnam Veterans and Rate Ratios, by Type of Circulatory System Disease (1965–1983)

Circulatory disease (ICD–9)	Vietnam		Non-Vietnam		Rate ratio*	95% CI
	No. deaths	Rate/ 100,000	No. deaths	Rate/ 100,000		
Hypertensive disease (401–405)	0	–	2	1.7	–	–
Ischemic heart disease (410–414)	7	5.5	11	9.1	0.60	0.23–1.56
Other heart disease (420–529)	4	3.1	5	4.1	–	–
Cerebrovascular disease (430–438)	1	0.8	3	2.5	–	–
Diseases of the arteries (440–448)	0	–	1	0.8	–	–
Other disorders of circulatory system (459)	0	–	1	0.8	–	–

*If the total number of deaths for a cause-of-death category in both groups combined was less than 10, the rate ratio is not shown.

Table 22. Number of Deaths Due to External Causes (from Death Certificate) and Crude Death Rates/100,000 Person-Years Among Vietnam and Non-Vietnam Veterans and Rate Ratios, by Specific Cause (1965–1983)

External cause (ICD–9)	Vietnam		Non-Vietnam			
	No. deaths	Rate/ 100,000	No. deaths	Rate/ 100,000	Rate ratio	95% CI
Motor-vehicle accidents (E810–E825)	81	63.3	52	42.9	1.48	1.04– 2.09
Accidental poisonings (E850–E869)	13	10.2	5	4.1	2.47	0.88– 6.92
Other accidents*	31	24.2	31	25.6	0.95	0.58– 1.56
Suicide (E950–E959)	29	22.7	28	23.1	0.98	0.58– 1.65
Homicide (E960–E969)	26	20.3	25	20.6	0.99	0.57– 1.71
Undetermined	8	6.3	2	1.6	3.79	0.81–17.87

*Includes accidental deaths other than motor vehicle accidents and accidental poisonings.

Table 23. Numbers of Deaths From External Causes (from Death Certificate) Among Vietnam and Non-Vietnam Veterans Combined and Unadjusted Rate Ratios, by Specific Cause and Time Since Discharge (1965–1983)

External cause	Years since discharge*					
	≤5 years			6+ years		
	No. deaths	Rate ratio	95% CI	No. deaths	Rate ratio	95% CI
Motor vehicle accident	66	1.93	1.16–3.22	67	1.16	0.72–1.87
Other accidents +	23	1.05	0.46–2.39	39	0.89	0.48–1.67
Suicide	25	1.72	0.76–3.88	32	0.64	0.32–1.30
Suicide + +	39	1.72	0.90–3.32	46	1.12	0.63–2.00
Homicide	18	1.52	0.59–3.91	33	0.78	0.39–1.56

*Number of deaths and RRs for "All years" of follow-up are presented in Table 22.
+ Includes accidental deaths other than motor vehicle accidents and accidental poisonings.
+ + Includes: accidental poisonings (E850–869), suicides (E950–959), injury undetermined whether accidentally or purposefully inflicted (E980–989) and ill-defined or unknown cause of death (799.9).

Table 24. Number of Deaths Among Vietnam and Non-Vietnam Veterans Combined and Unadjusted Rate Ratios* for Drug- and Alcohol-Related Causes (from Death Certificate), by Time Since Discharge (1965–1983)

	Years since discharge								
	≤5 years			6+ years			All years		
Cause +	No. deaths	Rate ratio	95% CI	No. deaths	Rate ratio	95% CI	No. deaths	Rate ratio	95% CI
Alcohol-related	4	–	–	17	1.73	0.64–4.66	21	1.27	0.52–3.00
Drug-related	15	1.93	0.66–5.64	11	2.50	0.66–9.44	26	2.13	0.93–4.91

*If the total number of deaths for a cause-of-death category in both groups combined was less than 10, the rate ratio is not shown.
+ See Section 3.1.3 for definitions of alcohol- and drug-related causes of death.

non-Vietnam veterans. When the rate ratios are examined by time since discharge, a 73% non-significant increase is seen in the later period of follow-up. Because information on alcohol use may not be consistently reported on death certificates for external causes, deaths from alcohol-related diseases are examined separately. Alcohol-related diseases include alcoholic psychoses (291.0-291.9), alcohol dependence syndrome (303), nondependent abuse of alcohol (305.0), alcoholic polyneuropathy, (357.5), alcoholic cardiomyopathy (425.5), alcoholic gastritis (535.3), alcoholic liver disease (571.0-571.3), and excessive blood level of alcohol (790.3). Nine of the 21 alcohol-related deaths are due to these causes; 3 occurred among Vietnam veterans and 6 in the non-Vietnam group.

Table 24 also shows that Vietnam service appears to be strongly associated with the likelihood of dying from a drug-related death. Overall, the rate of drug-related deaths among Vietnam veterans is 2.1 times that for non-Vietnam veterans. Furthermore, increased mortality among Vietnam veterans is seen not only in the first 5 years after discharge, but also in the subsequent time period.

4.3.2. Cause of Death Based on Medical Review

This section presents a re-analysis of selected ICD-9 cause-of-death categories based on review, by a panel of physicians, of available information relevant to the cause of death beyond the death certificate. It also includes a detailed examination of deaths associated with the use of alcohol and drugs as determined by the panel. First, a brief examination of differences between underlying causes of death derived from death certificates and those determined by the medical review panel is presented. Further detail is provided in Appendix E.

To arrive at the best judgment of underlying cause of death, we sought all pertinent documentation that might help to determine the nature and circumstances of the death. Information was obtained for 426 of the 446 total deaths: 95% (n=233) of Vietnam veteran deaths and 97% (n=193) of deaths among non-Vietnam veterans. Law enforcement records, autopsy reports, medical examiners' reports, and hospital records were the most common sources of information used by the medical review panel (Table 25). More supplemental records were available for non-Vietnam veterans than for Vietnam veterans from every source except hospitals and physicians. Significant differences in the availability of records between the cohorts are noted for law enforcement records, medical examiner's reports, and histopathology reports. The total number of available records also differed somewhat by cohort (Table 26). Four or more different types of records were obtained for 50% of non-Vietnam veteran deaths versus 45% of Vietnam veteran deaths.

The percent agreement and *kappa* statistic, quantifying agreement between the medical-review-panel cause of death and that from the death certificate, are presented in Table 27 for major cause-of-death categories. A more detailed examination of the agreement between medical-review-panel assignment of causes of death and death-certificate underlying causes is presented in Appendix E. Overall, there is good agreement (82%, *kappa*=0.79) between death-certificate and medical-review cause of death. Exceptionally good agreement is found for deaths due to neoplasms, MVAs, suicide, and homicide; for both Vietnam and non-Vietnam veterans, the *kappa* statistics for these causes are greater than 0.90. Poorer agreement is apparent for other causes of death, but most *kappa* values are based on small numbers and, therefore, are subject to considerable variation. All *kappa* values, however, are statistically significant at the 0.01 level, indicating that although agreement is poor in some categories, it is better than expected by chance alone.

Table 28 presents cause-specific mortality rates by cohort as determined by the medical review panel. For categories where formal analysis was possible, an elevated rate ratio for

Table 25. Information Sources Used by Medical Review Panel to Determine Cause of Death, by Place of Service

Source of information	Vietnam		Non-Vietnam	
	No. deaths	(% of all deaths)	No. deaths	(% of all deaths)
Law enforcement record*	124	(53.2)	121	(62.7)
Autopsy report	125	(53.7)	114	(59.1)
Alcohol level	126	(54.1)	108	(56.0)
Medical examiner's report*	117	(50.2)	115	(59.6)
Hospital record	109	(46.8)	85	(44.0)
Toxicologic report	78	(33.5)	76	(39.4)
Coroner's report	81	(34.8)	69	(35.8)
Histopathology report*	9	(3.9)	17	(8.8)
Physician's record	3	(1.3)	2	(1.0)
Other+	5	(2.2)	2	(1.0)

*$p<0.05$ (difference between percents for Vietnam and non-Vietnam veterans)
+Other sources of information were records obtained from the U.S. Bureau of Indian Affairs, the U.S. Bureau of Prisons, the National Personnel Records Center of the National Archives and Records Administration, local fire departments, funeral homes, and a single unsolicited verbal report from a next of kin who was contacted by telephone for permission to obtain medical records.

Table 26. Number of Information Sources Available to Medical Review Panel, by Place of Service

Number of sources*	Vietnam		Non-Vietnam	
	No. deaths	%	No. deaths	%
1	39	16.7	20	10.4
2	43	18.5	41	21.2
3	47	20.2	35	18.1
4	41	17.6	19	9.8
5	36	15.5	46	23.8
6	22	9.4	28	14.5
7	5	2.2	4	2.1
Total	233	100.0	193	100.0

*The number of information sources available to the medical review panel differed significantly between cohorts ($\chi^2_6 = 14.41$, $p = 0.02$).

Table 27. Percent Agreement and *Kappa* Statistic Between Death-Certificate and Medical-Review-Panel Cause of Death, by Selected Cause-of-Death Category and Place of Service

Cause of death (ICD–9)	Vietnam				Non-Vietnam			
	No. deaths*		Percent agreement	*kappa* +	No. deaths*		Percent agreement	*kappa* +
	DC	MR			DC	MR		
Neoplasms (140–239)	12	14	100.0	0.92	13	11	84.6	0.91
Mental disorders (290–319)	7	12	28.6	0.18	7	4	28.6	0.35
Circulatory diseases (390–459)	11	10	81.8	0.85	23	19	78.3	0.84
Respiratory diseases (460–519)	5	2	20.0	0.28	4	2	50.0	0.66
Digestive diseases (520–579)	5	6	40.0	0.35	2	6	100.0	0.49
Motor-vehicle accidents (E810–E825)	78	80	98.7	0.96	52	52	96.2	0.95
Accidental poisonings (E850–E869)	13	13	46.2	0.43	5	5	60.0	0.59
Suicide (E950–E959)	28	32	100.0	0.92	26	28	100.0	0.96
Homicide (E960–E969)	26	24	88.5	0.91	25	25	96.0	0.95
Undetermined intentionality (E980–E989)	8	6	12.5	0.12	2	3	50.0	0.39
Other causes	40	34	65.0	0.65	34	38	85.3	0.76

*DC = number of deaths determined from death certificate; MR = number of deaths determined by medical review panel.

+ All *kappa* values are statistically significant ($p<0.01$).

Table 28. Number of Deaths and Crude Death Rates/100,000 Person-Years Among Vietnam and Non-Vietnam Veterans, by Cause of Death (From Medical Review) (1965–1983)

Cause of death* (ICD–9)	Vietnam		Non-Vietnam		Rate ratio+	95% CI
	No. deaths	Rate/ 100,000	No. deaths	Rate/ 100,000		
Infectious diseases (001–139)	1	0.8	0	–	–	–
Neoplasms (140–239)	14	10.9	11	9.1	1.21	0.55–2.66
Endocrine, nutritional, and metabolic disorders (240–279)	0	–	1	0.8	–	–
Mental disorders (290–319)	12	9.4	4	3.3	2.85	0.92–8.82
Diseases of nervous system (320–389)	1	0.8	3	2.5	–	–
Diseases of circulatory system (390–459)	10	7.8	19	15.7	0.50	0.23–1.07
Diseases of respiratory system (460–519)	2	1.6	2	1.6	–	–
Diseases of digestive system (520–579)	6	4.7	6	4.9	0.95	0.31–2.84
Diseases of genitourinary system (580–611)	3	2.3	1	0.8	–	–
Diseases of musculoskeletal system (710–739)	1	0.8	0	–	–	–
Symptoms, signs and ill-defined conditions (780–799)	2	1.6	2	1.6	–	–
External causes (E800–E999)	181	141.5	144	118.7	1.19	0.96–1.48

*Cause-of-death categories that have no deaths assigned to them are not listed above.
+ If total number of deaths for a cause-of-death category in both groups combined was less than 10, the rate ratio is not shown.

Vietnam veterans is seen for deaths due to neoplasms, mental disorders, and external causes. Additionally, a lower death rate for Vietnam veterans is noted for circulatory diseases. None of the differences are statistically significant.

When rate ratios based on medical review were compared with those based on death certificates, two differences are apparent for causes with substantial numbers of deaths. The first category is neoplasms, with the rate ratio derived from medical review of 1.21, and a rate ratio of 0.82 from death certificates. This difference is primarily the result of two neoplasm deaths among non-Vietnam veterans being reclassified elsewhere and the opposite situation occurring among Vietnam veterans. (Details are available in Appendix E.)

When examining neoplastic deaths by time since discharge (Table 29), the rate ratio is similar in both periods of follow-up. Furthermore, among those followed for 11 or more years, there is no suggestion of differential mortality (three deaths among Vietnam veterans versus five among non-Vietnam veterans). Examination of specific types of cancer (Table 30) shows more deaths among Vietnam veterans from brain cancer, leukemia, and non-Hodgkin's lymphomas, all in very small numbers. The increase in the total number of malignant neoplasm deaths through medical review is primarily the result of confirming the malignancy of three brain tumors, all among Vietnam veterans. The nature of the tumor was not specified on the death certificate for any of the three. Finally, the three non-Hodgkin's lymphoma deaths among Vietnam veterans are the result of reclassifying two deaths among Vietnam veterans to lymphosarcoma (ICD-9, 200). These deaths were classified by the death certificate to cardiac arrest (ICD-9, 427.5) and acute lymphoid leukemia (ICD-9, 204.0). Further details are given in Appendix E.

Mental disorders is the second cause-of-death category for which there is a difference between the rate ratios obtained from medical review and death certificates. With the medical-review cause of death, a threefold risk is evident among Vietnam veterans, but the rate ratio is close to unity according to death-certificate causes of death. All "mental disorder" deaths, by either classification, involved alcohol or drugs. Differences in classification of these deaths is the result, in most cases, of a greater specificity in terminology used by the medical review panel. For example, in two cases the review panel cited alcoholic liver damage, unspecified (ICD-9, 571.3) as the underlying cause, whereas the death certificate wording limited the classification to alcohol dependence syndrome (ICD-9, 303). Alcohol- and drug-related deaths determined from medical review are examined in more detail below in this section.

Table 31 examines relative mortality for specific external causes of death as determined from medical review. These results are identical to those found from the death certificate analysis. Vietnam veterans are more likely than non-Vietnam veterans to die in motor vehicle accidents, from accidental poisonings and from injuries undetermined whether accidentally or purposely inflicted. The overall rate ratios are not significantly elevated for deaths due to suicide, homicide, and all other external causes. However, further exploration of external causes of death by time since discharge indicates the same pattern for MVAs, suicide, and homicide as seen in the death certificate results; the rate ratios are elevated in the first 5 years after discharge and are close to 1.0 for the remainder of follow-up.

Supplemental information collected for the medical review panel allowed further exploration of MVA deaths. Daytime and nighttime motor-vehicle-crash deaths as well as single and multiple vehicle events all occurred more frequently among Vietnam veterans during the early postdischarge period (Table 32).

We also examined the role of alcohol and drug use in motor vehicle accident deaths. Drug use information on MVA deaths was limited; the medical review panel identified only one

Table 29. Number of Deaths Due to Neoplasms (From Medical Review) and Crude Death Rates/100,000 Person-Years Among Vietnam and Non-Vietnam Veterans and Rate Ratios, by Time Since Discharge (1965 – 1983)

Years since discharge	Vietnam		Non-Vietnam		Rate ratio*	95% CI
	No. deaths	Rate/ 100,000	No. deaths	Rate/ 100,000		
≤5	5	10.8	4	8.9	–	–
6+	9	11.0	7	9.1	1.21	0.45–3.24
All years	14	10.9	11	9.1	1.21	0.55–2.66

*If total number of deaths for a cause-of-death category in both groups combined was less than 10, the rate ratio is not shown.

Table 30. Number of Neoplastic Deaths (From Medical Review) Among Vietnam and Non-Vietnam Veterans, by Specific Type (1965 – 1983)

Neoplasm type * (ICD – 9)	Vietnam	Non-Vietnam
Cancer of liver (155)	1	0
Cancer of lung (162)	0	2
Cancer of skin (172)	1	2
Cancer of testis (186)	2	2
Cancer of brain (191)	3	1
Cancer of ill-defined site (195)	1	0
Cancer of unspecified site (199)	0	1
Lymphosarcoma (200)	3	1
Hodgkin's disease (201)	0	1
Leukemia (204–208)	2	1
Neoplasms of uncertain behavior (235–238)	1	0

*Because of the small numbers of deaths in all categories, rates and rate ratios are not presented.

Table 31. Number of Deaths from External Causes (From Medical Review) and Crude Death Rates/100,000 Person-Years Among Vietnam and Non-Vietnam Veterans and Rate Ratios, by Specific External Cause (1965 – 1983)

External cause (ICD – 9)	Vietnam		Non-Vietnam			
	No. deaths	Rate/ 100,000	No. deaths	Rate/ 100,000	Rate ratio*	95% CI
Motor vehicle accidents (E810 – E825)	80	62.6	52	42.9	1.46	1.03 – 2.07
Accidental poisonings (E850 – E869)	13	10.2	5	4.1	2.47	0.88 – 6.9?
Other accidents	26	20.3	31	25.6	0.80	0.47 – 1.3?
Suicide (E950 – E959)	32	25.0	28	23.1	1.08	0.65 – 1.8?
Homicide (E960 – E969)	24	18.8	25	20.6	0.91	0.52 – 1.5?
Injuries of undetermined intentionality (E980 – E989)	6	4.7	3	2.5	–	–

*If total number of deaths for a cause-of-death category in both groups combined was less than 10, the rate ratio is not shown.

Table 32. Number of Motor-Vehicle-Accident (MVA) Deaths (From Medical Review) Among Vietnam and Non-Vietnam Veterans and Unadjusted Rate Ratios, by Type of MVA and Time Since Discharge (1965 – 1983)

Type of MVA death	Years since discharge					
	≤5 years			6+ years		
	No. deaths	Rate ratio	95% CI	No. deaths	Rate ratio	95% CI
Daytime*	16	2.90	0.93 – 8.98	24	1.11	0.50 – 2.48
Nighttime+	24	1.93	0.83 – 4.51	29	1.16	0.56 – 2.40
Single vehicle++	27	2.76	1.17 – 6.52	34	1.19	0.60 – 2.34
Multiple vehicles**	14	2.41	0.76 – 7.70	19	1.04	0.42 – 2.57

*MVAs occurring between 6:00 a.m. and 8:59 p.m.
+MVAs occurring between 9:00 p.m. and 5:59 a.m.
++ICD – 9, E815.0, E815.2, E816.0, and E816.2
**ICD – 9, E811.0, E811.2, E812.0, E812.2, E813.0, and E813.2.

drug-related MVA death. Blood alcohol level information or the suspected involvement of alcohol was available for 82 (62%) of the 132 medically reviewed MVA deaths. Table 33 shows that in the initial follow-up period, there is a weak relationship between Vietnam service and alcohol-related MVAs (RR=1.35) in contrast to a stronger relationship for MVAs that are not alcohol-related (RR=2.25). The pattern of risk for MVAs with "unknown alcohol involvement" is similar to that for "no alcohol involvement."

The agreement between the death certificate and medical review panel for alcohol- and drug-related deaths is presented in Table 34. Twenty-one deaths are defined as "alcohol-related" from death certificates and 133 from medical review. This lack of agreement is evident regardless of the specific type of alcohol-related death; the *kappa* statistic ranges from 0.11 for accidental causes to 0.44 for alcohol-related natural causes of death. The overall agreement for drug-related deaths is much better than that for alcohol-related deaths, but for specific categories the agreement is poor.

Overall there is a slight excess of alcohol-related deaths among Vietnam veterans (Table 35), due mainly to accidents. Deaths from alcohol-related natural causes and deaths due to alcohol-related suicide, homicide and injuries of undetermined intentionality are not associated with service in Vietnam.

The distribution of drug-related deaths by cohort is presented in Table 36. Overall, Vietnam veterans are 1.6 times as likely to die from drug-related deaths as non-Vietnam veterans. Suicide by drugs is a very minor component of this excess. Moreover, as shown in Table 37, when the follow-up interval is subdivided into three time periods, the RRs appear to increase over time, with a substantial excess of drug-related deaths in the most recent years of observation.

Although based on a small number of deaths, the drug-related mortality excess appears to be limited to Vietnam veterans who were drafted into service and those whose jobs involved tactical or combat operations (see Appendix D, Table D-3). Additionally, there is some suggestion that those discharged during 1970 or after had a greater excess of drug-related deaths. However, when we examine the year in which the veteran served in Vietnam as opposed to his date of discharge, it appears that the drug-related excess is especially high among Vietnam veterans who were stationed in Vietnam during 1968 or 1969 (RR=4.93, 95% CI=1.14-21.34). The rate of drug-related deaths is similar between Vietnam and non-Vietnam veterans serving before (RR=1.20) and after (RR=0.71) that time period.

4.3.3. Consideration of Covariates

Table 38 presents adjusted rate ratios based on a Cox regression model for cause-specific death categories with sufficient numbers of deaths for formal analysis. Adjusted values are based on a model stratified on MOS and enlistment status, and including age, race, GT score, pay grade at discharge and year of discharge. Rate ratios based on death-certificate cause of death and medical-review cause of death are both presented. In the early follow-up period, adjustment increases the RR for suicide based on death-certificate cause of death from 1.72 to 2.54 and, based on the medical review data, from 1.64 to 2.47. Pay grade at discharge and GT score are the covariates that have the greatest effect on the adjusted suicide estimate. Adjustment also had some effect on the RR for alcohol- and drug-related deaths based on the death-certificate data. For alcohol-related deaths, the RR increased from 1.73 to 2.23 in the later follow-up period while the RR for drug-related deaths in the initial follow-up period increased from 1.93 to 2.86.

Table 33. Number of Motor-Vehicle-Accident (MVA) Deaths (From Medical Review) Among Vietnam and Non-Vietnam Veterans and Unadjusted Rate Ratios, by Alcohol Involvement and Time Since Discharge (1965–1983)

Alcohol involvement	Years since discharge								
	≤5 years			6+ years			All years		
	No. deaths	Rate ratio	95% CI	No. deaths	Rate ratio	95% CI	No. deaths	Rate ratio	95% CI
Yes*	24	1.35	0.60–3.04	29	1.16	0.56–2.40	53	1.23	0.72–2.13
No +	10	2.25	0.58–8.71	19	1.04	0.42–2.57	29	1.34	0.64–2.81
Unknown + +	31	2.36	1.08–5.13	19	1.29	0.52–3.21	50	1.84	1.03–3.31

*MVA deaths (ICD–9, E810–E825, E929.0) for which either nondependent abuse of alcohol (ICD–9, 305.0) is cited as a contributing cause of death or for which there is a recorded blood alcohol level of at least 100 mg%.

+ MVA deaths for which alcohol abuse is not cited as a contributing cause of death and for which there is a recorded blood alcohol level of less than 100 mg%.

+ + MVA deaths for which alcohol abuse is not cited as a contributing cause of death and for which there is no recorded blood alcohol level.

Table 34. Number and Type of Alcohol- and Drug-Associated Deaths Based on Death Certificates and Medical Review, with Associated Percent Agreement and *Kappa* Statistic

Cause of death*	No. deaths		Percent agreement	*Kappa* statistic
	Death certificate	Medical review		
	Alcohol-associated			
Natural causes	9	30	100.0	0.44
Accidents	8	65	62.5	0.11
Suicide, homicide, injury of undetermined intentionality	4	38	75.0	0.13
Total	21	133	85.7	0.16
	Drug-associated			
Drug dependence and abuse	8	28	62.5	0.26
Accidental poisoning by drugs	10	10	50.0	0.49
Suicide or poisoning by drugs, intentionality undetermined	8	2	12.5	0.19
Total	26	40	92.3	0.71

*See Section 3.1.3 for definitions of alcohol- and drug-associated deaths.

Table 35. Number and Type of Alcohol-Associated Deaths (From Medical Review) and Crude Death Rates/100,000 Person-Years Among Vietnam and Non-Vietnam Veterans and Rate Ratios (1965 – 1983)

Type of death*	Vietnam		Non-Vietnam		Rate ratio	95% CI
	No. deaths	Rate/ 100,000	No. deaths	Rate/ 100,000		
Natural causes	16	12.5	14	11.5	1.08	0.53 – 2.22
Accidents	37	28.9	28	23.1	1.25	0.77 – 2.05
Suicide, homicide, and injury of undetermined intentionality	19	14.9	19	15.7	0.95	0.50 – 1.73
Total	72	56.3	61	50.3	1.12	0.80 – 1.57

*See Section 3.1.3 for definitions of alcohol-associated deaths.

Table 36. Number and Type of Drug-Associated Deaths (From Medical Review) and Crude Death Rates/100,000 Person-Years Among Vietnam and Non-Vietnam Veterans and Rate Ratios (1965 – 1983)

Type of death*	Vietnam		Non-Vietnam		Rate ratio	95% CI
	No. deaths	Rate/ 100,000	No. deaths	Rate/ 100,000		
Dependence and abuse	17	13.3	11	9.1	1.47	0.69–3.13
Accidental poisoning by drugs	6	4.7	4	3.3	1.42	0.40–5.04
Suicide or poisonings by drugs, undetermined intentionality	2	1.6	0	–	–	–
Total drug-associated deaths	25	19.5	15	12.4	1.58	0.83–3.00

*See Section 3.1.3 for definitions of drug-related deaths.

Table 37. Number of Drug-Associated Deaths* (From Medical Review) and Crude Death Rates/100,000 Person-Years Among Vietnam and Non-Vietnam Veterans and Rate Ratios, by Time Since Discharge (1965 – 1983)

Years since discharge	Vietnam		Non-Vietnam		Rate ratio +	95% CI
	No. deaths	Rate/ 100,000	No. deaths	Rate/ 100,000		
≤5	10	21.6	8	17.9	1.21	0.48–3.06
6–10	8	17.4	5	11.3	1.54	0.50–4.71
11+	7	19.6	2	6.2	–	–
All years	25	19.5	15	12.4	1.58	0.83–3.00

*See Section 3.1.3 for definition of drug-associated deaths.
+If the total number of deaths for a cause-of-death category in both groups combined was less than 10, the rate ratio is not shown.

Table 38. Unadjusted and Adjusted* Rate Ratios Based on Death Certificate and Medical Review Cause of Death, by Selected Cause of Death and Time Since Discharge (1965 – 1983)

Cause of death+	Death Certificate				Medical Review			
	≤5 years		6+ years		≤5 years		6+ years	
	Unadjusted RR	Adjusted RR	Unadjusted RR	Adjusted RR	Unadjusted RR	Adjusted RR	Unadjusted RR	Adjusted RR
Neoplasms	0.81	0.83	0.82	0.68	–	–	1.21	1.07
Circulatory diseases	–	–	0.60	0.60	–	–	0.56	0.51
Motor vehicle accidents	1.93	1.98	1.16	1.22	1.89	1.96	1.16	1.22
Suicide	1.72	2.54	0.64	0.57	1.64	2.47	0.78	0.74
Homicide	1.52	1.46	0.78	0.85	1.38	1.35	0.73	0.82
Alcohol-related	–	–	1.73	2.23	1.42	1.67	0.99	0.97
Drug-related	1.93	2.86	2.50	2.99	1.21	1.56	2.02	2.57

*Adjusted values are from a Cox Proportional Hazards Model, stratified on MOS and enlistment status, and controlled for age, race, GT score, year of discharge, and pay grade at discharge.

+ If the total number of deaths for a cause-of-death category in both groups combined was less than 10, the rate ratio is not shown.

4.4. COMPARISON OF VETERAN AND U.S. DEATH RATES

Presented in Table 39 are the observed and expected numbers of deaths from all causes for the two veteran cohorts stratified by the number of years since discharge from active military service. Over the total follow-up period, both groups of veterans have a significantly lower mortality rate for "natural causes" than the general U.S. male population. However, during the first 5 years after discharge, Vietnam veterans have a higher death rate from external causes whereas non-Vietnam veterans have a lower rate relative to the general population. In the later time period both groups of veterans show a similar deficit in external cause mortality.

Standardized mortality ratios for major natural cause-of-death categories are given in Table 40. Among Vietnam veterans the SMRs for most natural causes of death are below 1.0, with the exception of deaths due to diseases of the genitourinary system (SMR=2.53, 95% CI=0.82-5.89). For diseases of the circulatory system, the deficit of deaths in Vietnam veterans is much greater (52%) than for non-Vietnam veterans (13%). Both cohorts experienced lower-than-expected mortality for diseases of the digestive system and neoplasms.

The SMRs for specific external causes (Table 41) show an excess of deaths among Vietnam veterans due to accidental causes, mainly from motor vehicle accidents. Suicide mortality is at the same level as that in the general population in the Vietnam cohort. Among non-Vietnam veterans, the SMRs for specific external causes are all at or below 1.00, indicating no excess of deaths relative to the general population experience.

Table 39. Observed and Expected Numbers of Deaths by Cause (From Death Certificate) Among Vietnam and Non-Vietnam Veterans and Standardized Mortality Ratios, by Time Since Discharge (1965 – 1983)

Years since discharge	Cause of death* (ICDA – 8)		Vietnam	Non-Vietnam
≤5	All natural causes (000–796)	Observed	13	16
		Expected +	24.2	23.4
		SMR + +	0.54	0.68
		95% CI	0.29–0.92	0.39–1.11
	External causes (E800–E999)	Observed	92	55
		Expected	72.5	69.4
		SMR	1.27	0.79
		95% CI	1.02–1.56	0.60–1.03
6+	All natural causes (000–796)	Observed	38	39
		Expected	65.8	63.4
		SMR	0.58	0.62
		95% CI	0.41–0.79	0.44–0.84
	External causes (E800–E999)	Observed	96	88
		Expected	102.7	96.6
		SMR	0.93	0.91
		95% CI	0.76–1.14	0.73–1.12
All years	All natural causes (000–796)	Observed	51	55
		Expected	90.0	86.6
		SMR	0.57	0.63
		95% CI	0.42–0.75	0.48–0.82
	External causes (E800–E999)	Observed	188	143
		Expected	175.2	166.0
		SMR	1.07	0.86
		95% CI	0.93–1.24	0.73–1.01

*Excludes 9 deaths (7 Vietnam, 2 non-Vietnam) for which death certificates were not recovered.

+ Expected number is based on the mortality rates among U.S. males, standardized for age, calendar year, and race.

+ + SMR = Observed deaths/expected deaths.